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Sufficiency – A Scoping Paper

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List of Abbreviations

CCS	Carbon capture and storage
CCU	Carbon capture and use
CREDS	Centre for Research into Energy Demand Solutions
CT	Carbon Tax
DG	Directorate General
EC	European Commission
EEA	European Environment Agency
EED	Energy Efficiency Directive
EEF	Energy Efficiency First
EP	European Parliament
EPBD	Energy Performance of Buildings Directive
ESR	Effort Sharing Regulation
ETS	Emission Trading Scheme
EU	European Union
FEC	Final energy consumption
NECP	National Energy and Climate Plan
IPCC	Intergovernmental Panel on Climate Change
IoT	Internet of Things
LED	Low energy demand
LTS	Long-term strategy
LULUCF	Land use, land use change and forestry
MS	Member State (of the EU)
NECPR	National Energy and Climate Progress Report
PaMs	Policies and measures
PBC	Personal Carbon Budget
pc	Per capita
PCA	Personal Carbon Allowance
PCT	Personal carbon trading
PEC	Primary energy consumption
Pkm	Person-kilometres
PtL	Power-to-Liquid
SDGs	Sustainable Development Goals
SPM	Summary for Policymakers
Tkm	Tonne-kilometres
TP	Trends and projections report

Summary

The aim of this scoping paper is to provide a comprehensive overview of the concept of sufficiency and to show or recommend how it could be operationalised in the context of EU or national policymaking. Furthermore, open questions related to sufficiency are named and partly discussed in the different parts of the paper. These can be seen as proposals for future research. They are **printed in bold** to make them easier to find in the text.

In the first – theoretical – part, the concept of sufficiency is introduced and explained, reasons why it should be included in future policymaking are given and the different actors and notions of sufficiency as well as its mitigation potential are described.

In the second part, we describe energy consumption developments and compare them with EU targets, we analyse different EU processes on the occurrence and importance of sufficiency and present backgrounds and implementation examples from France as well as other interesting policy approaches for fostering sufficiency followed by recommendations how knowledge, data and analyses on sufficiency could be fostered.

For both parts, we reviewed a broad set of literature on sufficiency and did own data analysis.

The key findings of this scoping paper are:

1. Sufficiency is more than behavioural change
2. Sufficiency is pivotal to reach deep sustainability
3. Sufficiency has a lot of multiple benefits
4. Sufficiency has a high mitigation potential
5. Energy reduction is unambitiously addressed in the EU
6. Political sufficiency is not mainstream yet
7. Citizens call for more sufficiency policy
8. A budget approach would support sufficiency
9. We need more sufficiency modelling and indicators
10. We lack studies on the economic dimension of sufficiency

PART 1: Theoretical background

1 What is sufficiency?

The concept of sufficiency is gaining more attention in science and policymaking – as shown in the number of studies, scenarios, and papers on sufficiency. Even in the IPCC Sixth Assessment Report, which for the first time includes a chapter on demand-side solutions[1], sufficiency (policy) is mentioned and defined in a footnote.

However, there is not yet a consensus on a definition of sufficiency, but various definitions exist or are being developed in the expanding literature building upon earlier ones. In the following subchapter we present four currently used definitions around the term sufficiency. The one from IPCC on sufficiency policy and three on energy sufficiency because most of sufficiency literature is currently linked to energy and climate change mitigation topics. We point to the similarities and differences of the definitions in the first subchapter. Furthermore, we describe how the definitions relate to the concepts of the "doughnut economy" and "consumption corridors", which are closely interlinked with sufficiency.

In the second subchapter we explain the differences and overlaps of the sufficiency concept to the concepts of efficiency and consistency and in the third subchapter we present policy examples for sufficiency for different sectors to make sufficiency more illustrative.

1.1 Definitions in literature and related concepts

- The IPCC (2022) defines sufficiency policies as "*a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human wellbeing for all within planetary boundaries*." (p. 35)
- Thomas et al. (2019) state: "*In terms of its objectives, energy sufficiency is a strategy aiming at limiting and reducing the input of technically supplied energy towards a sustainable level.*" (p. 1125)
- In a concept paper, Darby und Fawcett (2018) developed the definition "*Energy sufficiency is a state in which people's basic needs for energy services are met equitably and ecological limits are respected.*" (p. 8)
- In an analysis of sufficiency in current political strategies of EU Member States (MS) Zell-Ziegler et al. (2021) developed the working definition: "*Energy sufficiency is the strategy of achieving absolute reductions of the amount of energy-based services consumed, notably through promoting intrinsically low-energy activities, to reach a level of enoughness that ensures sustainability.*" (p. 2)

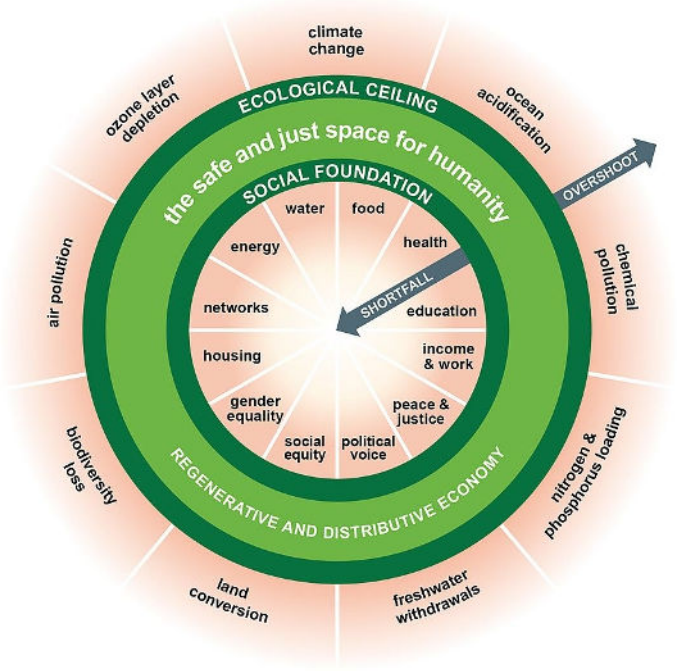
All definitions relate to maintaining a balance between resources and consumption, which shall be kept via sufficiency. The balance is kept by not transgressing boundaries that have been called either "planetary boundaries" according to Rockström et al. (2009), "ecological limits" or just "sustainable level" or "level of enoughness that ensures sustainability". Some of the definitions also explicitly link sufficiency to goals other than ecological ones, which can be reached via sufficiency, namely "human wellbeing for all" and "people's basic needs for energy services". Linking sufficiency to these human

[1] When it comes to wording, relevant terms besides sufficiency are demand-side options/solutions, energy saving and also efficiency which sometimes includes sufficiency because both strategies aim at a lower energy consumption.

goals comes from the concept of the "doughnut economy"[2] which was put in practice by the concept of "consumption corridors" (Fuchs et al. 2021).

The "doughnut economy" is intended to serve as "a compass for human progress this century" and was developed in 2017 by Kate Raworth, a British economist. In her concept "The Doughnut of social and planetary boundaries" she addresses the challenge of various societal goals as well as boundaries. The doughnut consists of an outer ring, the "ecological ceiling" including *nine planetary boundaries* according to Rockström et al. (2009) and an inner ring, the "social foundation" including *twelve dimensions based on the Sustainable Development Goals*. Outside of the boundaries it comes to either shortfall (social side) because basic human needs are not met or an overshoot (ecological side) where ecological boundaries are transgressed; however, in-between the rings is "the safe and just space for humanity" where it can thrive, see Figure 1.

Figure 1: The Doughnut of social and planetary boundaries



Source: Illustration by DoughnutEconomics[3], CC BY-SA 4.0

Researchers around Doris Fuchs applied this concept to consumption issues and proposed the concept of "consumption corridors". A consumption corridor is the space defined by the doughnut of Raworth (see light green space in Figure 1) and sustainable consumption must respect both the ecological ceiling and the social floor (Fuchs et al. 2021).

Most of the definitions specify that energy demand or consumption must be avoided / limited / reduced to what is necessary (in absolute terms). Definitions on the broader concept of sufficiency emphasise that consumption of other (public) goods like materials, land and water must also be

[2] https://www.kateraworth.com/doughnut/
[3] https://commons.wikimedia.org/w/index.php?curid=75695171

reduced accordingly. The link to the concept of consumption corridors makes it clear, however, that sufficiency does not relate to a precarious use of energy – energy services must explicitly be guaranteed to all humans. Another important aspect in some of the definitions is that sufficiency is not uniquely driven by technological innovations, but also by changes in "daily practices" and by the adoption of "intrinsically low-energy activities".

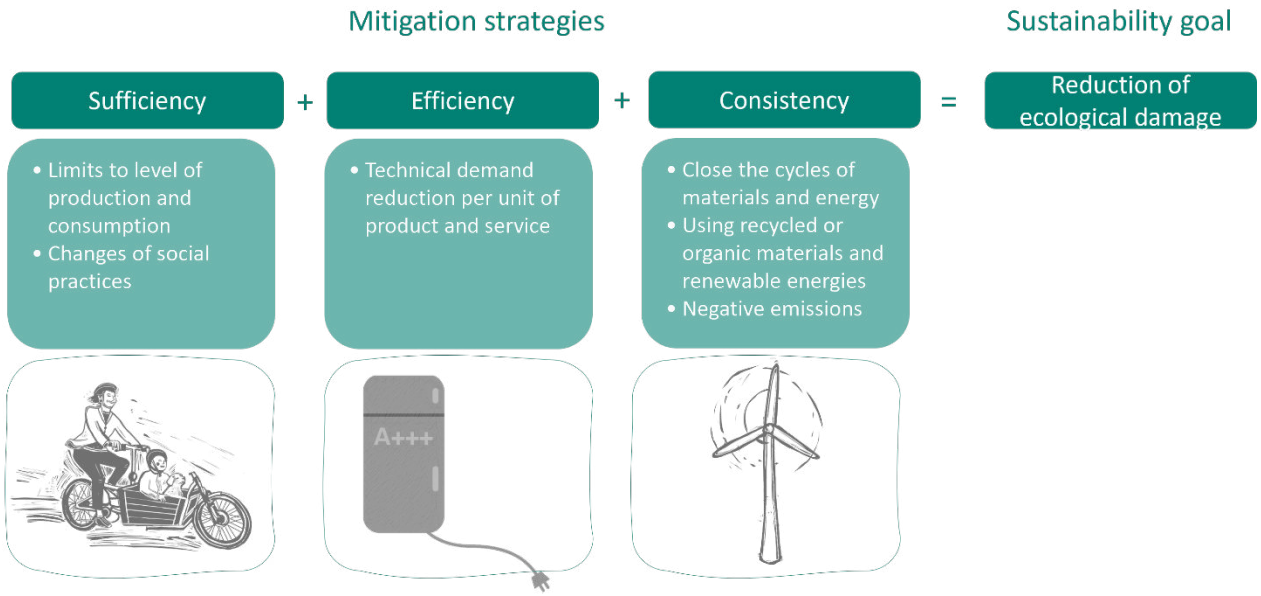
The currently co-existing definitions of sufficiency also have differences: some emphasise that sufficiency is a strategy while others define sufficiency as a state or goal in itself. See Lage (2022) who digs deeper into the different notions of sufficiency by different authors.

1.2 Differences to and overlaps with the mitigation strategies of consistency and efficiency

In its ecological dimension, sufficiency is a strategy to mitigate climate change and support decarbonisation. Other mitigation strategies are energy consistency and efficiency, see Figure 2 and e.g. Brinken et al. (2022).

There are some main differences but also overlaps between the concepts which will be described in the following section besides defining consistency and efficiency.

Figure 2: Three mitigation strategies to obtain the sustainability goals



Source: Illustrations by Sarah Heuzeroth[4] for Oeko-Institut, equation adapted from Huber (1995) & Huber (2000)

The strategy of consistency looks for alternative technologies and materials that are better for nature and the environment than previous ones and tries to close loops from production to use and recycling to reuse (BUND 2022). The term "consistency" is mainly used in the German context, in the international discourse the sub-strategies of consistency like expansion of renewable energies or electrification are the prevailing terms (see e.g. IEA (2021) for a good overview of possible decarbonisation options, clustered via the chapters in the report). Some studies also term consistency as substitution.

[4] https://www.sarah-heuzeroth.de/impressum/

The strategy of Circular Economy is an operationalisation of consistency. It can be described as “a regenerative system, driven by renewable energy that replaces the current linear ‘take-make-dispose’ industrial model. Materials are instead maintained in the economy, resources are shared, while waste and negative impacts are designed out. A sustainable Circular Economy creates positive environmental and society-wide benefits and functions within planetary boundaries supported by an alternative growth and consumption narrative.” (WWF 2020).

In this definition of Circular Economy, there are links and overlaps with the sufficiency definitions, like the reference to the planetary boundaries and social benefits. A policy that can be attributed to both sufficiency and consistency is e.g. prolonging the use time of appliances by extending their warranty time or indicating their reparability[5]. The goal of keeping resources longer in the system is relevant for both concepts.

However, both strategies have different and sometimes conflicting aims. That is why it is emphasised in the sufficiency literature that the first focus of decarbonisation efforts must be to lower energy consumption before trying to cover all energy needs with renewable energy (consistency). Furthermore, it is warned that there will be resource and other constraints when the business-as-usual fossil energy consumption shall be one to one replaced by renewables (Wiese et al. 2022).

The expansion of renewable energies and the reduction of energy consumption (sufficiency/efficiency) does not always go hand in hand. Studies have shown that there is a risk of a rebound effect when using renewable energy: households producing their own energy are more likely to increase their energy consumption rather than decreasing it (Schuler et al. 2019).

The next strategy for decarbonization is efficiency. The IPCC (2018) states in its glossary: “Energy efficiency is often described by energy intensity. In economics, energy intensity describes the ratio of economic output to energy input. Most commonly energy efficiency is measured as input energy over a physical or economic unit.” And: “Very often in policy ‘energy efficiency’ is intended as the measures to reduce energy demand through technological options such as insulating buildings, more efficient appliances, efficient lighting, efficient vehicles, etc.” (IPCC 2018a, p. 548). And Bund für Umwelt und Naturschutz Deutschland e.V. (BUND) (2022) adds that “generally, efficiency aims at a more productive use of raw materials and resources, often through technical innovations” (translated).

Rebound effects are also commonly observed with efficiency: even though the energy intensity by unit is reduced, this is often (over-)compensated by an increase in the energy service demand (Chenavaz et al. 2021). Examples of this are the following:

- a more efficient car engine reduces the fuel need per km, but cars are getting heavier and larger and/or the distances travelled increase.
- through insulation of buildings, the energy demand per square meter decreases but the living space per person increases or the room temperature is increased.

The rebound effects coming with efficiency measures make clear that a focus on the relative reduction of energy consumption is not enough for reaching our mitigation targets without also addressing the absolute reduction of energy consumption and energy consuming service demands like transport needs or living spaces (Toulouse et al. 2017).

[5] https://www.indicereparabilite.fr

The IPCC (2022) and the German Council of Experts on Climate Change (Expertenrat für Klimafragen 2022) point to these activity levels that drive our energy consumption and state that their reduction is key. To address this, a certain change of perspective is necessary. Possible policy implications of this mind-shift can be:

- Changes in city planning so that places of daily need are closer to the places of residence to reduce mobility needs. This links to the concept of wants and needs by Max-Neef (1991). He states that going from A to B is a mobility "need", but this does not necessarily need to be fulfilled by a car (that is often used alone) – driving by car should be called a "want" to be distinguished from the mobility "need" (Max-Neef 1991).
- In terms of resources changes to product identification and/or pricing like an indication of the expected lifetime and/or a pricing per year of the expected lifetime on electronic devices to put low prices more into perspective.
- Introduction of incentives to lower energy / resource etc. demand: Guarantee for stable flat rent per square metre if people move to a smaller, more adequate flat and give room to families that need more space.

Wolfgang Sachs, a thought leader in sufficiency stated in 1999 "While efficiency is about doing things right, sufficiency is about doing the right things" (Sachs 1999).

A list of possible sufficiency policies by sector is given in chapter 1.3, planned or implemented sufficiency policies are described in chapters 6 and 7.

Despite these differences, the concepts of sufficiency and efficiency have the same goal of reducing energy demand (even though efficiency focuses mainly on relative reduction, sufficiency on absolute). That is why there are overlaps when looking at concrete policy instruments, e.g. taking the bus instead of the personal car is on the one hand more effective in terms of fuel by person-kilometre but it can also be categorised as sufficiency because it is a low-energy alternative to the personal car coming with behavioural change. Moreover, policies like information campaigns or education for reducing energy demand, energy saving networks, CO_2 prices in general, can fall both as sufficiency and efficiency policies.

1.3 Example sufficiency policies for different sectors

To illustrate what is understood as a sufficiency policy we list a few examples per sector in the table below. Some sufficiency policies have overlaps with the efficiency or consistency strategies as explained in the subchapter above. Furthermore, assignment to the sufficiency strategy can be narrow or broadly defined. A narrow scope would mean to only consider policies aiming at an absolute reduction of energy service demands like travelled distance. We use a broader scope and also include policies aiming at a shift of (energy/material/land consuming) practices, e.g. from individual motorised to public transport. In the cross-sectoral field we also consider policies that could aim at a reduction of e.g. energy use like a CO_2 tax.

Table 1: Examples of sufficiency policies for different sectors

Sector	Possible measures	Policy example
Buildings	reduce per capita living space / heated floor area	possibility for two parties to exchange flats without rent increase per m²
	increase co-living-concepts that reduce the privately used area	investment grants for housing cooperatives that provide small flats and attractive commonly used spaces
Mobility	ban private cars from certain areas in favour of more sustainable mobility	designation of car free city centres / concept of "Superblocks"[6] in Barcelona
	use public transport or active modes instead of energy and resource consuming electric scooters	stop the free sharing of electric scooters
	freight modal shift to rail or waterways (from road/air)	extend and increase freight toll on roads
	increase teleworking	right to teleworking / subsidies for equipment
Production / Consumption	increase repairability and/or the lifetime of products	increase warranty period for appliances to 10 years / obligatory information on minimum lifetime on products
	reduce unused products	ban quantity discounts ("buy one, get one free")
Agriculture / Nutrition	reduce meat consumption / incentives for plant-based diets	voluntary self-commitment of employers/cantines to follow WHO-recommendations
	reduce food waste	development of a network of distribution and food platforms
Cross-sectoral	campaigns on energy savings	awareness campaigns in social media

Source: Zell-Ziegler et al. (2021), European Sufficiency Policy Database

More examples of sufficiency measures or policies in the different sectors can be found in the European Sufficiency Policy Database. The almost 300 policies listed there will be complemented with best practice examples and emission saving potentials where available in the coming months.

[6] https://ajuntament.barcelona.cat/superilles/en/

2 Necessity of energy sufficiency

Energy sufficiency can bring upon several benefits that we will look at in this chapter. In addition to climate change mitigation and limiting the exploitation of planetary boundaries, benefits can also be more equality and justice, health and quality of life. The sufficiency strategy is especially characterised by these multiple benefits which are a reason why we conclude that energy sufficiency is necessary to solve the multiple crises we face.

At the end of this chapter, we discuss rebound effects and socio-economic as well as political implications of sufficiency which are often part of societal debates about the concept.

2.1 To mitigate climate change

Sufficiency deals with adjusting lifestyles to maintain planetary boundaries, by adjusting policy measures and everyday behaviours to reduced consumption and demand of energy, materials, land, water, and resources, while maintaining quality of life to all population within the planetary boundaries (Saheb 2022). Despite lots of measures and policies introduced over the last thirty years for climate mitigation, humanity has failed so far to get on track for reaching targets such as the 1.5°C target of the Paris Agreement (Stoddard et al. 2021), and as result, more incisive measures seem to be necessary, such as sufficiency. Sufficiency has been lauded as a strategy that can compensate for the lack of success of previous efforts.

As previously seen, efficiency and sufficiency are strategies that mainly contrast in that efficiency is about short-term technological improvements while not taking into account planetary boundaries explicitly. The sufficiency strategy is a very targeted one because it is defined as a strategy to reach the 1.5°C target, thus avoiding dangerous climate change. It therefore focuses more on the long-term; furthermore, it is driven by human needs and wellbeing and non-technological solutions. Therefore, it is proposed that sufficiency is a demand side solution and efficiency a supply side one (Princen 2003).

Sufficiency focuses on behavioural and lifestyle changes while questioning the infrastructures and framework conditions we live in which are not only physical infrastructures but also the paradigm of ever-increasing growth and the culture of consumerism/overconsumption. With sufficiency, there is a new strategy of setting aside smaller individual actions and the over-dependency on technologies, which ultimately, with efficiency, replaces technology by further technologies without accounting for material demand or embodied energy. In the IPCC report on the 1.5°C target (IPCC 2018b) it is depicted that we either massively rely on technologies and negative emissions or need lifestyle changes to reach the target. Due to its demand-side approach affecting lifestyles, sufficiency is, however, often seen as a controversial measure.

Mitigation potentials through sufficiency have been quantified already: developed countries could reduce their emissions by 30% (Saheb 2022). More on mitigation potentials can be found in chapter 4.

2.2 To not further exceed other planetary boundaries

Energy use also has implications on other planetary boundaries (esp. biodiversity and land use). Rockström et al. (2009) demarcated the term of planetary boundaries defining nine primordial variables that make the earth habitable. These variables include, among others, climate change, land-system change, atmospheric aerosol loading, or ocean acidification. Each of the nine variables has a proposed safe operating space that is defined by a critical value for different indicators within

the variables, for example CO_2 concentrations. The data and figure[7] has been updated several times, see Steffen et al. (2015) and Wang-Erlandsson et al. (2022).

Not overshooting the planetary boundaries and preserving the natural capital is a key element and prerequisite to keep the earth habitable and to ensure deep (or strong) sustainability (Buriti 2019). The way to not exceed them is to make a sustainable use of the resources of the planet. Sufficiency, by definition, aims at not exceeding these limits which is illustrated by the "Doughnut of social and planetary boundaries" (see Figure 1). In a more comprehensible way for the public, the "Earth Overshoot Day"[8] by the Global Footprint Network[9] wants to stress exactly this.

In terms of climate change, it is proposed that to avoid its most damaging impacts, global temperature increase should be limited to 1.5°C above pre-industrial levels. Global temperature is, as of 2022, 1.1°C higher than at the end of the 19th century. To keep to the 1.5°C limit and the respective CO_2 budget, as proposed by the Paris Agreement, greenhouse gas emissions need to be drastically reduced – by 45 % by 2030 to globally reach net zero latest in the middle of this century. It has been argued that such targets cannot be achieved without the implementation of measures that we would subsume as sufficiency (United Nations 2022).

2.3 With regard to resource consumption

An increase in energy production from renewable energy sources has impacts on the exploitation of natural resources and meets / will meet constraints on resources in general as well as constraints on rare earth materials. Moreover, import dependencies for resource needs are a critical issue. Furthermore, resource extraction is often linked to ecological and ethical problems and can conflict with SDGs.

Conserving the resources of the planet is a key aspect to maintaining ecological and social balance as well as for not exceeding the planetary boundaries. Several technologies that contribute to the reduction of greenhouse gas emissions have limitations in their potential due to the resources they require. This is mainly relevant for energy production from photovoltaics, hydrogen and wind, electricity transmission, and (battery-)electric vehicles because they require large amounts of rare materials that cannot be found in abundance on the planet (DERA 2021). Especially for wind and solar production, the infrastructure required to reach the 2050 targets is massive (Kleijn und van der Voet 2010).

According to Kleijn and van der Voet (2010), for each of the main GHG emission-reducing technologies, there are specific scarce materials that render the technology unsustainable. More specifically, thin-film solar panels require rare elements (Cadmium, Tellurium, Selenium, Gallium, Indium, Germanium, and Ruthenium), depending on the type of panel. The electric motors of wind turbines with permanent magnets need neodymium to increase the efficiency of the turbine, while reducing maintenance costs and the weight of the generators. Around 150 kg of neodymium is needed per MWe in wind turbines (Polinder et al. 2006), technological innovation and recycling are expected to reduce the pressure on resource extraction (Alves Dias et al. 2020).

Finally, both electrolysers for hydrogen production based on alkaline processes and fuel cells in cars require platinum for effective performance (Koroneos et al. 2004). It is estimated that platinum world reserves are 80,000 tons, and it is expected that by 2050, only for the 2 billion electric cars on the

[7] https://www.pik-potsdam.de/en/news/latest-news/planetary-boundaries-update-freshwater-boundary-exceeds-safe-limits
[8] https://www.overshootday.org/
[9] https://www.footprintnetwork.org/

roads by 2050, 39,000 tons would be needed – without taking into account the platinum needed for electrolysers. To run the planet with renewable energy, different technologies should be used or developed that do not put a strain on the planet's resources and do not require rare materials.

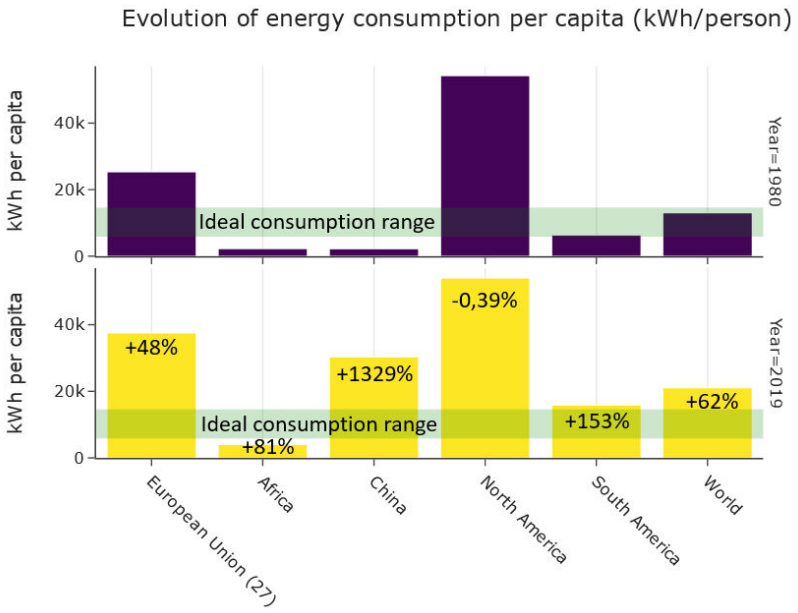
Copper, chromium, and steel would also be required to be used in extreme quantities for hydrogen pipelines, wind turbines and for electricity transmission. Transmission through copper by 2050 could require up to 70 times the yearly production of 2010; with an additional 4 times for the current production for the wind turbines needs (Kleijn und van der Voet 2010). Steel production would need to be six times more the production of 2010 only for the wind turbines requirements and for the hydrogen pipelines an increase by 40 % would be needed. Although not all materials needed for GHG emission reducing technologies are rare or scarce, such as copper and iron, their extraction and mining is currently done with fossil fuels, requires large amounts of energy as well as area which is critical for biodiversity conservation and partly has critical working conditions at the extraction sites (Martin und Iles 2020; Rehbein et al. 2020; Farley 2022).

2.4 Relation to just energy transition

The large differences in the use of energy by the average world citizen show a situation of "energy inequality", with the top 10 % emitters (individuals who emit more than 2.3 times average emissions) contributing to 45 % of world emissions (Chancel und Piketty 2015). According to figures from the portal "Our World in Data"6F10, North Americans used on average 53,994 kWh/pc in 2019, all energy uses included. In contrast, the average European citizen uses a 30 % energy less, with 37,497 kWh/pc, and the average Chinese a 44 % less with 30,322 kWh/pc. These figures significantly deviate from a 1.5°C compatible pathway with an annual maximum of 14,595 kWh/pc (1,255 kgoe/pc) as suggested by the "Global Commons Institute's Contraction and Convergence" (Darby 2007; Steinberger und Roberts 2010). However, there is an inability of some citizens (especially in Africa) to reach minimum energy requirements (established in 5,815 kWh/pc by the Millennium Project of the UN Development Program). Figure 3 illustrates these differences by superposing an estimated "ideal consumption range" based on the abovementioned sources to the evolution of consumption followed by different world actors.

[10] https://ourworldindata.org/per-capita-energy

Figure 3: Evolution of energy consumption per capita across different areas between the year 1980 and 2019.



Source: own representation

Note: Values include energy used in residential sector, transportation, manufacturing, power production and other sectors. Green shaped area illustrates the theoretical upper and lower thresholds of an ideal consumption. Percentages show increase or decrease in consumption between the years.

As pointed out by the "Demand Centre" in a thought-provoking article published in 2018[11], an important aspect to consider when estimating the "minimum requirement" is the consideration that what seems sufficient today, might not be it tomorrow. This statement that proves to be true with the continuous market launch of new products (home appliances, IoT devices, etc.), inquires on the emergent need to define "basic energy services".

In a recent paper, Shyu (2021) discusses the concept of "right to energy" by citing the minimal standards proposed by the Poor People's Energy Outlook (PPEO)[12] to ensure basic human needs at the households level (including lighting, cooking and water heating, space heating, cooling, and information and communications). These standards suggest, for instance, a minimum daytime indoor air temperature of 18°C and a maximum of 30°C or the people's right to communicate electronically from their household. Ensuring a minimum access to energy represents a fundamental right as acknowledged by the UN SDG7: Affordable and Clean Energy and it should be part of all national energy policies.

In this line, the EU27 is unfolding an ambitious program to ensure that all Europeans benefit from the opportunities of the energy transition while optimising their consumption. The combination of private (€10-15 billon) and public (€18.5 billion) investment will be enriched by specific investments encompassed under the Just Transition fund mechanisms (€25.4 billion) to support the transition towards a more sustainable and fair use of energy in the Union[13]. Furthermore, the proposed Social Climate Fund will include up to €65 billion for the years 2026-2032 to support energy poor people

[11] https://www.resilience.org/stories/2018-01-29/how-much-energy-do-we-need/

[12] https://practicalaction.org/poor-peoples-energy-outlook/

[13] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

and businesses to deal with price increases in the buildings and transport sector due to their inclusion into the ETS[14].

It is however less clear how these investments will account for the concept of sufficiency. Experts highlight the need for the promotion of responsible consumption behaviours and the support to collective approaches (Shyu 2021), aspects only scattered in the EU plan for the Just Transition fund. Unlocking sufficiency requires human awareness and action which relies in its turn on educational campaigns and favourable policies. **The implementation of sufficiency schemes is still unknown and requires further understanding on what an effective implementation entails** (Sorrell et al. 2020). In the same line, it is important to deal with potential distributional effects emerging from the implementation of sufficiency policies. Climate policies can lead to negative side effects that require specific understanding, as it has been documented with the EU ETS implementation where carbon cost ended up "being passed" through to products in the consumption basket of low-income households (Zachmann et al. 2018). Similarly, the quality of the accessed energy also represents an important factor to account when it comes to sufficiency. For many households, the provision of energy relies on highly polluted sources that have side effects on the health of the occupants of the household.

Unlocking the opportunities of the energy transition for the citizens is not only a national but a transnational challenge. If only rich or developed countries are able to benefit from the technological and behavioural changes driven by the energy transition (electrification, uptake of local renewable energy sources (RES), collective approaches, digitalisation services, etc.), the human pressure on the planet is likely to remain at similar levels as nowadays. This is mainly due to the fact that developing countries might increase the use of the non-renewable resources not used by its peers in the other countries.

2.5 Multiple benefits

Health, quality of life, and wellbeing

Sufficiency measures may have a positive impact on the health and quality of life of consumers. The reduction of consumption and growth can bring upon a better balance between wealth, time availability, relationships, and other meaningful activities (Zannakis et al. 2019). Common health issues caused by stress and overworking, such as burnout, may be less prevalent with the reduction of consumption since a reduction in consumption can trigger increased financial security, liberty, and autonomy, and therefore devote extra time to spending quality time with family or friends (O'Sullivan und Kraisornsuthasinee 2019; Hook et al. 2021). This goes in line with the philosophy of voluntary simplicity or minimalism: reducing one's possessions, consumption, and paid employment. Further definitions expanded the term to refer to concepts of ecological and social awareness and responsibility (Elgin und Mitchell 1977). Several studies have suggested that there is a positive correlation between voluntary simplicity and wellbeing. This correlation may be explained by the reduction of consumption which can bring upon a reduction of urges to buy possessions or energy, which in its turn provides a bigger satisfaction to ones needs, such as autonomy, relatedness, and competence. Physical health is another aspect that could be improved by adopting sufficient lifestyles, by being more physically active (like cycling) and by reducing the emission of pollutants from combustion processes (Creutzig et al. 2022; Paech 2012).

[14] https://www.consilium.europa.eu/en/infographics/fit-for-55-social-climate-fund/

Freedom, equality, global justice

Environmental issues in Western societies tend to be linked to three core values of liberal societies, namely freedom, no-harm principles, and social justice (Huppenbauer und Müller 2016). Sufficiency is related to the actions of individuals in societies (and the political design of good framework conditions to be able to live a sustainable life), specifically when the actions are related to values and attitudes adopted to avoid harming other individuals or social justice. In other words, a sufficient lifestyle deals with a "good life" in relation to environmentally friendly behaviour, therefore a lifestyle that encourages behavioural patterns that reduce environmental impacts. This reduction in environmental harm is also an advance of freedom for future generations as well as for people mostly affected by climate change and other environmental problems. Therefore, sufficiency can be a link between global justice, more equality and freedom.

When only looking at Western societies with their (on average) affluent lifestyle and overconsumption, the sufficiency concept with restrictions on consumption can also be a great threat to personal freedom. It will be on the political decision makers to find ways of shaping infrastructures and social practices to be sustainable while at the same time keeping a certain freedom of choice for individuals to be compatible with the values of a liberal society (Fischer und Grießhammer 2013). Read more on this in chapter 2.7.

In a certain corridor (see chapter 1.1), sufficiency can then be a free choice on reduced and avoided consumption. For people living below the corridor, their freedom is of course to consume more to be able to live a good life (Heindl und Kanschik 2016).

2.6 Sufficiency and rebound effects

By adopting sufficiency measures and lifestyles of sufficiency elements, citizens can enjoy several of the benefits brought upon by such lifestyles, from improved health and wellbeing to more time. Yet, by changing one's behaviour and different aspects of lifestyles, other behaviours may be formed, and these could lead to rebound effects.

Rebound effect is a term that was developed by the energy economics to describe a number of processes that hinder the anticipated energy savings forecasted by the implementation of energy efficient measures (Sorrell 2007). These effects have been widely studied and reported for energy efficiency measures in the literature, in particular in economics and behavioural psychology studies. It is surmised that comparable processes occur when energy sufficiency measures are implemented; however, these have been less studied and are less understood.

Three of the major differences between efficiency and sufficiency measures is that sufficiency measures do largely not reduce the cost of the service; they often do not need investment on a certain technology; and they often require less or even no maintenance costs. Thus, energy sufficiency measures can increase the income, and as a result, such costs represent smaller fractions of the total income. Therefore, a spill-over effect in this respect is that the leftover income may be re-spent in further services that require energy. Different socioeconomic groups will consume goods and services differently, depending on their expenditure elasticity. More specifically, the consumption of normal goods tends to increase with income while inferior goods decrease. The rebound effect size can be dependent on the re-spending pattern: goods with low energy over emissions intensity may yield larger effects. As an example, if a household does not use cars, savings will come in the shape of no insurance, maintenance, taxes, or fuel needed.

According to Sorrell et al. (2020), rebound and spill-over effects are secondary results from energy sufficiency measures and improvements. It is suggested that energy efficiency measures can reduce the prices of the specific energy services, as opposed to energy sufficiency measures. Efficiency actions are linked to income effects (effect on increased purchasing power) and substitution effects (changes in consumption depending on relative prices); while sufficiency actions are only linked to income effects. Furthermore, according to Sorrell et al. (2020), the consumers' motivation for efficiency improvements tends to be financial benefits as opposed to that of sufficiency improvements which is reducing emissions. This difference is likely to have an effect on the resulting spillover effect (Santarius und Soland 2018). Finally, efficiency improvements lead to time-related rebound effects only if associated to improvements in time efficiency. In other words, consumers may choose a more time efficient alternative, if there is an anticipation for higher demand of the service. It is therefore proposed that consumers can reduce their carbon footprint by adapting more sufficient behaviours; it is only possible to do it consistently if the actions cover a wide scope of domains emphasising actions with larger effects on energy use and emissions. Heating and electricity consumption actions tend to have smaller rebound effects while the effects are larger with actions involving transportation and food consumption. However, the size of the effects is highly depending on the re-spending patterns of the consumers.

Spill-over effects are linked to people's environmental values, as a result, the weaker the values the more negative the effects.

2.7 Societal debates about sufficiency and socio-economic as well as political implications

This section proposes that the adoption of sufficiency may shift the balance in a negative manner, especially with its effects on policies, society, and economics. The section is divided in two parts, first sufficiency policies and their effect on freedom and how to develop policies that can encourage sufficiency without taking quality of life from the citizens. This is followed by a section on the implications on economy of sufficiency adoption.

Personal freedom vs regulation to implement sufficiency-oriented behaviours

A switch of paradigm towards sufficiency is related to the achievement of several sustainable development goals. One of the most common definitions given of sustainable development is that of World Commission on Environment and Development, stated that it is a development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). The definition further emphasizes that the needs of the poor and vulnerable should be prioritized, also elaborating on the fact that the definition implies that limitations should be imposed by the state of technology and social organisation on the ability to meet past and future needs (World Commission on Environment and Development 1987). Authors have suggested that attaining and satisfying needs brings about improved quality of life which is also a central goal of sustainable development and hence sufficiency (Rauschmayer et al. 2011). In order to satisfy these needs, sustainable development policies and regulation addressed to individuals, businesses, and administrations aim at improving quality of life while solving environmental and social problems. This brings the debate of what are the motivations towards sufficiency and sustainability.

Kleinhückelkotten (2005) has proposed that sufficient strategies may lead to lower consumption levels, yet they may shift the balance in intra- and intergenerational justice. This is due to the need to develop measures such as rules, standards and bans (Heyen 2022). Authors have proposed that such measures are better accepted by the public when they are introduced along supporting

measures such as subsidies and information, since this can shift the motivations of people to the target behaviour from being external to internal (Drews und van den Bergh 2016). Creating intrinsic motivations towards pro-environmental, pro-social, and sustainable behaviours should therefore be key during the development of measures, by focusing on the psychological empowerment of people. Another model that has been proposed to balance the regulation-freedom system is the dynamic norm-activation model (Schwartz und Howard 1981). The model, on the one hand allows for normative goals that will ensure the freedom to citizens to live a valuable life, while encouraging pro-social behaviours and sufficiency-oriented lifestyles. Such normative goals can also be fostered by increasing the participation of citizens at early and different stages of the development of environmental policies, by means of focus groups, questionnaires, and surveys (Kuntze und Fesenfeld 2021).

Another relevant area that is still not included in climate governance is the reduction and regulation of emissions and the ecological footprint of the world's rich and very rich people, as there is a large "carbon inequality" (Chancel 2022; Chancel und Piketty 2015), as already mentioned in chapter 2.4. **There is a lack of effective policy instruments and proposals and political courage to address this issue of equity.** The narrative of personal freedom is very strong in this milieu.

Implication on economy, transport and building sectors

A frequent criticism to sufficiency is that it may be opposite to growth and indeed, the sufficiency concept questions continued economic growth and leads the debate towards other indicators of wellbeing or a "sustainable welfare state" where GDP growth would no longer be the most important indicator of the economy and where the social systems would no longer be dependent on GDP growth[15].

As long as the focus is on GDP, however, some sufficiency scenarios explore this connection: The négaWatt Association proposes that sufficiency doesn't mean a general decline of the economy (Association négaWatt, 2018). Rather, several alternative sectors can develop further with the adoption of sufficiency measures, such as clean means of transportations, plant-based diets, local tourism, amongst others, they also see a net positive balance for jobs. The négaWatt scenarios show numbers that correspond to an evolution in the period between 2010 to 2050 and are based on average values of the French metropolitan population, and therefore don't translate in a uniformed manner to all sectors and households, as these can vary per situation and capacity. Another assessment of the economic consequences of a low-energy net-zero pathway is presented in (Climact 2018). They state that "net-zero pathways can cost less than business-as-usual and build a more prosperous, resilient society" (p. 3). Another example like this is given at the end of chapter 5.2.

Examining the impact of a shift to sufficiency on GDP and employment, on the one hand, and how to create a sustainable welfare state and reduce our dependence on GDP growth, on the other, is crucial for successful sufficiency policy and broader engagement with the concept by policymakers and other societal actors.

The transportation sector is the highest GHG emission sector in France, négaWatt developed a scenario (Association négaWatt 2022a) with a combination of measures that allow for a continuation of a quality lifestyle while being more sufficient. Such measures in transportation, among others, are to reduce the maximum speed limit from 130 to 110km/h, in which case fuel consumption could be

[15] https://www.mdpi.com/journal/sustainability/special_issues/sustainable_welfare_beyond_growth

reduced by 25%, while only increasing the commuting time of eight minutes for every 100 km. Furthermore, teleworking should be encouraged to reduce the travelled distances (Association négaWatt 2018).

In the building sector, there is more than thermal renovation strategies for saving energy consumption, as there is a potential of sufficiency in the design and development of buildings, their use, and management. In France, at the current building rate, in 2050 there would be 365 million square meters more for industrial buildings and 4 million extra accommodations (residential buildings, in addition to the existing surface, in spite that the population is expected to only increase by 6 %. Trends also suggest that for every dwelling there will be only 2.0 occupants by 2050 (as opposed to 2.2 in 2018), and there is a trend of less cohabitation. Sufficiency measures can counter these trends, such as encouraging cohabitation and more people living in more surface area. In the négaWatt scenario (Association négaWatt 2022a) the number of occupants per dwelling stays at the 2018 level so that 3 million accommodations do not need to be built. Another measure would be to reduce the number of newly built individual dwellings and smaller floor areas for newly built dwellings. A further measure proposed is to create more common spaces for people and activities.

NégaWatt also suggests that generally, a greater moderation in the use of electrical appliances and lighting could be exercised. Although appliances are becoming increasingly energy efficient, the trend since the 1970s has been that electricity consumption has increased six times, as people surround themselves with more appliances. It is therefore proposed by the scenarios of négaWatt that there should be 20 % fewer dryers, a substitution of freezers by combination of fridge and freezers, and the ownership of a single TV per household. As far as lighting is concerned, it has been suggested that a rebound effect has taken place since the introduction of LED bulbs, by installing further light fixtures in buildings or as streetlighting. NégaWatt suggests a scenario in which there should be a 20 % reduction of light fixtures by 2050, in relation to 2015. Similarly, their usage time should be reduced by 10 % in households and by 35% in the tertiary sector.

3 Who is addressed, and which role can these actors play?

Since the introduction of the concept by Sachs in 1993 (Sachs 1993), sufficiency has been mainly seen as an individual strategy to reduce one's carbon footprint – and this is probably the current main association citizens have with the concept, if they have ever heard of it. The scientific discourse is a lot wider and describes the different actors and addressees of sufficiency beyond that (a main publication about sufficiency *policy* is Schneidewind und Zahrnt 2013). In a recent review, Lage (2022) compares the different notions of sufficiency and categories them into three types of transformation paths with different foci.

Lage's paper is the basis for this chapter where we describe these three types he identified. Other sources complement the explanations, especially Best und Zell-Ziegler (2022) as well as the ones mentioned below.

3.1 Individual consumer behaviour / "bottom-up approach"

The high resource consumption of the 'global consumer class' (Spangenberg und Lorek 2002, S. 128) comes with a strong responsibility for reducing consumption and suggests a large reduction potential. This concept is aimed at voluntarily reducing consumption, which relies on individual realisation of the problem and cultural change. Sufficiency builds on the ecological reflection of the individual consumption behaviour, since it is seen as an informed and intentional decision (Schmidt und Weigt 2015, S. 209).

Individual consumption reduction means consuming less per capita overall. This presupposes certain capacities for action and, in the sense of self-responsibility, is compatible with liberal dogmas of freedom.

However, the potential of this approach is limited because a mass, voluntary self-deprivation of the global middle and upper classes is very unlikely. Further, individual changes can be hindered due to legal regulations, social norms or organisation of wage and care work.

Next to consumers, Lage also categorises businesses into this first notion of sufficiency for bottom-up sufficiency transformation. They are key actors in mainstreaming sufficiency-oriented practices. They can influence consumers by shifts in e.g. sale strategies, development of business models and respond to changes in consumer behaviour. However, if changes are made within businesses, the focus is to shift to 'greener' products and processes rather than reductions in consumption.

3.2 Framework conditions set by politics / "Policy-making approach"

Lage's second type emphasises the embeddedness of societal practices in framework conditions like physical infrastructures and social or mental structures. Accordingly, there is a necessity for political change to make a sufficient lifestyle become easier. Policy instruments of different levels of intervention can be used to favour sufficiency, such as taxes and incentives, improvements or changes to existing infrastructure, or regulations and bans. One major critique is that those policies would restrict the individual liberties (see section 2.7), however sufficiency policies raise the questions of intergenerational justice which is at least the same level or above liberty questions.

This path presupposes a strong state supplemented by participatory processes to implement sufficiency strategies in both consumption and production. So far, wide-ranging sufficiency policies are seldom found in practice. In the end, it relies on the realisation of necessity by policy makers.

3.3 “Social-movement approach”

Social movements emphasise the role of power and interests. They question the current system with its dependencies and constraints, often with the aim of bringing about fundamental systemic change. In doing so, social movements are often oriented towards approaches critical of globalisation and growth and aim for egalitarian, democratic and ecologically sustainable forms of the economy and society in which a more conscious use of energy and resources plays an important role. It needs drastic movements and confrontations to shift power structures and increase political pressure. At the centre of political sufficiency demands is the need to promote practices of care and community to meet human needs in a less materialistic way and a focus on redistribution.

However, in this type the implementation of sufficiency seems more unlikely and unclear than for the other two types. The concepts of the social-movement approach are more difficult to translate into concrete measures and instruments.

4 The emission mitigation potential of sufficiency

A crucial question is how the mitigation potential of sufficiency is. The latest IPCC report and other literature sources provide insights into and data on this. Furthermore, scenarios modelling the decarbonisation pathway for the EU or single countries can show what is possible. We present some selected findings in the following subchapters.

4.1 Mitigation potentials found in the literature

The most prominent mitigation potentials on sufficiency can be found in the latest IPCC report (IPCC 2022). In figure 6 of the SPM of Working Group III of the 6th Assessment Report they are shown for the year 2050 together with other demand-side mitigation options. Sufficiency is included in the categories “socio-cultural factors” and partly “Infrastructure use” as well as “demand-side mitigation options” in the electricity sector. In total, IPCC (2022) states that demand-side options can mitigate 40-70 % GHG emissions in 2050 compared to 1990.

Figure 4: Mitigation potentials of demand-side options including sufficiency (global focus)

Source: IPCC (2022), figure SPM.6[16]

Another publication on demand-side mitigation strategies (Creutzig et al. 2022) analysed more than 50,000 papers and compiled their mitigation potential. We extracted the results for the sufficiency options and present them in Table 2.

[16] https://www.ipcc.ch/report/ar6/wg3/figures/summary-for-policymakers/figure-spm-6

Table 2: Emission reduction potentials of sufficiency strategies (global focus)

Mitigation strategy	Range of CO2e emissions reduction potentials
Building design, size and use (behavioural and lifestyle change), also includes compact-city- and nature-based solutions from urban sector	10–40% (central value, 25%)
Avoid: active travel in highly accessible cities; teleworking supported by compact, highly accessible city design and safe infrastructures for pedestrians and cyclists. Teleworking or telecommuters partially or entirely replace their out-of-home work activities by working at home or at locations close to home	0–25% (central value, 10%)
Shift: shared mobility and convenient and safe public transit. Pooled shared mobility with high occupancy and micro-mobility with high lifetime of vehicle stock; convenient rail-based public transit; supported by urban design and transit-oriented development, resulting in reduced travel distances; logistic optimization in last-mile freight.	0–25% (central value, 15%)
Avoid: flights. Aviation is of low economic value and demand is highly sensitive to prices. A carbon price of aviation fuel of US$400 /tCO2 would halve demand for aviation in 2050.	0–47% (central value, 40%)
Avoid: reduce demand and slow steaming. Shifting supply chains, lower demand for consumption goods and slow steaming of ships would reduce shipping demand substantially.	40–60% (central value, 47%)
Avoid: food waste (overconsumption not further considered, as diets rich in calories—and, in particular, sugar—add little to GHG emissions).	8–25% (central value, 15%)
Shift: animal-free protein. Switch to animal-free protein sources such as soy, lentils, other pulses and meat substitute products.	18–87% (central value, 40%) (applies to farm-gate GHG emissions)
Avoid: materials-efficient services. Avoid materials via dematerialization, the sharing economy, material-efficient and lightweight designs and yield improvements in manufacturing.	5–22% (central value, 13%)
Avoid: lifespan extension. Designing products so that their lifetime can be extended through repair, refurbishing and remanufacturing, instigated via standardization, modularity and functional segregation.	3–7% (central value, 5%)
Shift: reuse and recycling. Increasing the reusability and recyclability of product components. Example: dismantle old cars and reuse components for repairing other cars.	4–7% (central value, 5%)
Building design, size and use (behavioural and lifestyle change), also includes compact-city- and nature-based solutions from urban sector	10–40% (central value, 25%)

Source: Extract from Creutzig et al. (2022), table 1

The study by (Vita et al., 2019) contains more small-scale potentials for a broad range of consumption decisions from a lifecycle point of view and shows which of them are most effective. This view is quite interesting for sufficiency because it also accounts for embedded emissions. It also shows mitigation potentials beyond emission reduction (toxicity, land and water), see Figure 5.

Figure 5: Mitigation potentials of different consumption options (European focus)

Table 5

Environmental synergies and trade-offs of green consumption and sufficiency scenarios. Mitigation potential (green and positive) or backfire (red and negative) expressed as a percent difference (Δ) with respect to the baseline. Color-coding as follows: yellow: Δ ± 2%; light red: Δ < −2%; dark red: Δ < -5%; light green: Δ > 2%; dark green: Δ > 5%. Yellow color represents small and thus uncertain results. The outcome of these actions would depend on their practical implementation. The values summarize the percentages reported in Fig. 2.

Consumption domain	Green Consumption Scenarios	Mitigation potential				Sufficiency Scenarios	Mitigation potential			
		Carbon	Toxicity	Land	Water		Carbon	Toxicity	Land	Water
Clothing	Animal Free (Ctrl)	-0.8%	-0.5%	-1.2%	-0.5%	Local Clothing	0.5%	1.7%	0.3%	0.5%
	Natural Fibers	0.0%	-0.1%	-0.3%	-0.3%	Durable fashion	1.8%	2.5%	2.1%	2.1%
Construction	Repair & Renovate	-0.7%	2.4%	-10.8%	1.0%	Minimum Construction	1.8%	1.3%	3.5%	0.5%
	Natural Materials	0.5%	0.1%	-1.4%	0.0%	Work				
Food	Mediterrenean Diet*	2.7%	0.2%	-0.1%	-0.5%	Food Sufficiency* (Ctrl)	4.9%	2.6%	14.4%	16.0%
	Vegetarian*	6.4%	3.0%	0.6%	0.2%	Local Food	0.6%	3.6%	0.1%	0.1%
	Vegan*	13.9%	9.0%	4.7%	14.8%	Organic Food	1.8%	1.0%	0.8%	1.3%
	Healthy Vegan*	15.7%	12.0%	-2.9%	9.7%	Seasonal Food	0.1%	0.0%	0.0%	0.0%
						Less Waste	2.1%	1.1%	5.5%	7.1%
Manufactured Products	Share Repair	4.3%	6.2%	2.7%	2.5%	Less Chemicals & Plastics	3.9%	4.0%	2.7%	4.4%
						Offline minimalist	1.5%	2.0%	0.6%	0.6%
						Durable Appliances	1.5%	2.0%	1.0%	0.7%
Transport	Less Cars (50%)	8.8%	1.7%	0.8%	0.6%	Less Transport (50%)	14.5%	20.4%	2.0%	1.9%
	Renewable Fuels	12.1%	1.4%	-5.9%	-5.3%	Work from Home (50%)	13.0%	7.1%	1.9%	1.8%
	No Flying	2.3%	1.0%	0.3%	0.2%	Work from Home (50%) ER	8.9%	6.1%	-1.0%	1.2%
	Cycling & Flying (Ctrl)	0.1%	1.3%	0.3%	0.4%	Only Bike and Walk	26.0%	14.2%	3.8%	3.5%
Services	Community Services	3.1%	23.8%	3.6%	6.6%	Local Services	5.3%	2.9%	0.8%	0.7%
						Non-market Services	17.8%	21.5%	14.6%	15.8%
Housing	High Tech Ecovillage*	7.9%	1.3%	1.7%	0.3%	Low Tech Ecovillage	13.8%	4.9%	4.9%	2.6%
	Renewable Electricity*	2.9%	0.2%	-3.1%	-0.1%	Water Off Grid	0.5%	0.2%	0.1%	0.1%
	Passive House	5.6%	1.9%	5.0%	1.1%					

Mitigation Potential (high certainty) | Uncertain (implementation matters) | Risk of backfire

Source: Vita et al. (2019), table 5

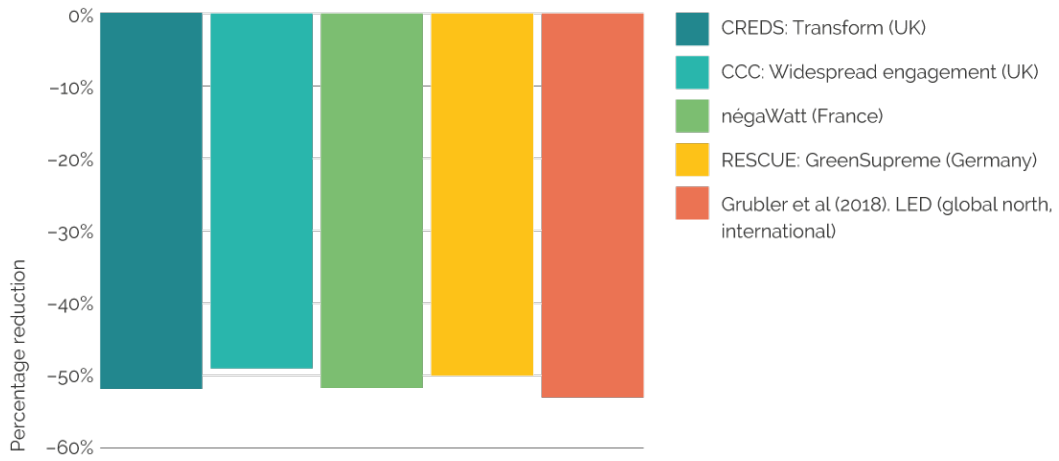
The presented studies are examples of the existing – and growing – literature on sufficiency mitigation potentials. **It will be crucial to also use the potentials in energy modelling, policymaking processes, and societal debates. To make them more visible and usable, a central database on existing quantifications would be desirable.**

4.2 Sufficiency modelling examples

So far, there are very little ambitious decarbonisation scenarios including sufficiency upfront (also referred to as low energy demand / LED scenarios). An analysis of five of them by CREDS in 2022[17] showed that concerning FEC, they are quite similar with around 50 % reduction between 2020 and 2050.

[17] https://www.creds.ac.uk/a-cross-country-comparative-analysis-of-low-energy-demand-scenarios-in-europe/

Figure 6: Overview of FEC reduction between 2020 and 2050 for five sufficiency scenarios



Source: CREDS (2022)[17]

CLEVER: A European sufficiency scenario

An example for sufficiency modelling is the CLEVER scenario, which was developed by partners from several European countries, coordinated by the French négaWatt Association. First results were published in December 2022, the final report in June 2023[18].

It is worth taking a closer look at this scenario. It is quite ambitious because it uses the budget approach and wants not only to reach net-zero by 2045 but be compatible with the remaining budget for keeping the 1.5°C target of the Paris Agreement. Furthermore, it is very conservative in using certain technologies: It does not assume new nuclear power plants and CCS and only assumes very few CCU as well as PtL. It is also conservative with bioenergy use and the assumptions on natural sinks are in line with the EU LULUCF objectives for 2030. In 2050, there is 100% supply with renewable energy for the whole of Europe and there are no energy imports after 2045.

FEC reduction between 2020 and 2050 is -50 % and there is convergence among countries on energy service levels e.g. living space/pc. Therefore, corridors for certain energy services were defined in the project and all countries needed to converge until 2050, so either decrease or increase their demands to match the corridor. More on this process can be found in their sufficiency briefing note (Clever 2022).

[18] https://clever-energy-scenario.eu/

PART 2: Sufficiency in the EU and policies of EU member states – an analysis of the status quo, implementation examples and recommendations

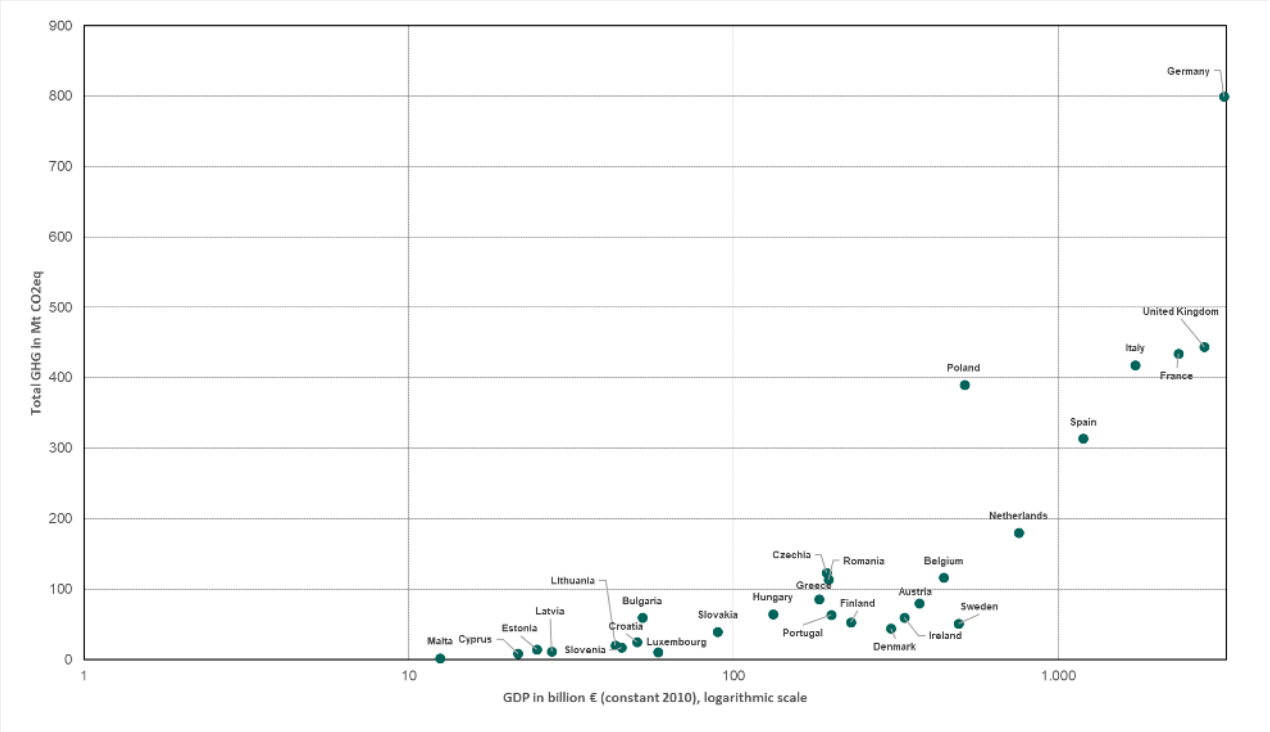
5 Emissions and energy consumption in the EU

In this chapter we have a look at historic, current, and projected emissions and primary energy consumption (PEC) as well as final energy consumption (FEC) in the EU and its member states.

5.1 Correlation between emissions and GDP

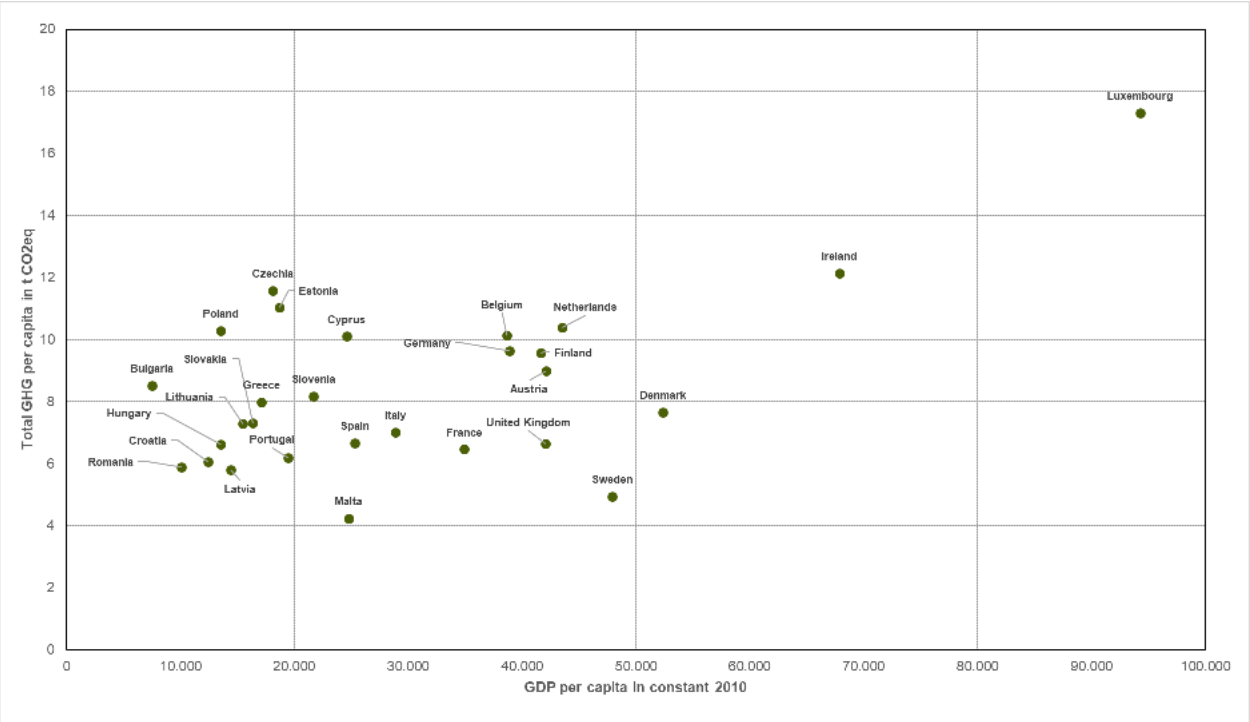
Emissions correlate to a large extent with income and economic growth, as shown many times in the literature, see e.g. Onofrei et al. (2022). Also, for the EU countries, GDP correlates significantly with total GHG emissions with a correlation coefficient of 0.9 (absolute GDP) and 0.6 (GDP per capita) as can be seen in Figure 7 and Figure 8.

Figure 7: Emissions and GDP per country absolute for 2019 (logarithmic scale)



Source: own representation based on European Environment Agency (EEA) (2022) and Eurostat (2022)

Figure 8: Emissions and GDP per country and per capita for 2019



Source: own representation based on European Environment Agency (EEA) (2022) and Eurostat (2022)

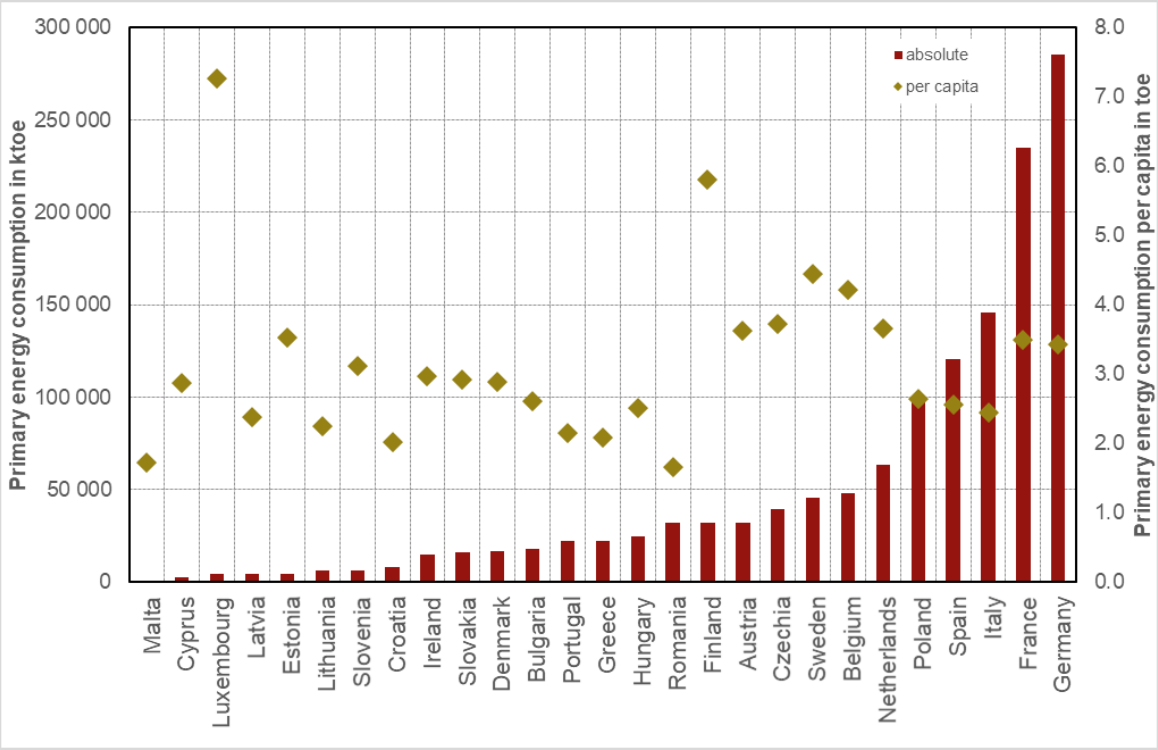
Decarbonisation strategies and plans often call for a decoupling of emissions and GDP because decarbonisation cannot be successful without it. The EU is already on a good way, see European Commission (2022, figure 4), however, the question is if the pace of the decoupling is sufficient. Decoupling is moreover not only needed for emissions but also other aspects like land consumption, biodiversity, and resource use.

Examples in the field of the latter are rare so far, as an extensive review study shows (Haberl et al. 2020): “Large rapid absolute reductions of resource use and GHG emissions cannot be achieved through observed decoupling rates, hence decoupling needs to be complemented by sufficiency-oriented strategies and strict enforcement of absolute reduction targets”, the authors of the review conclude (p. 1).

5.2 Primary and final energy consumption development and targets

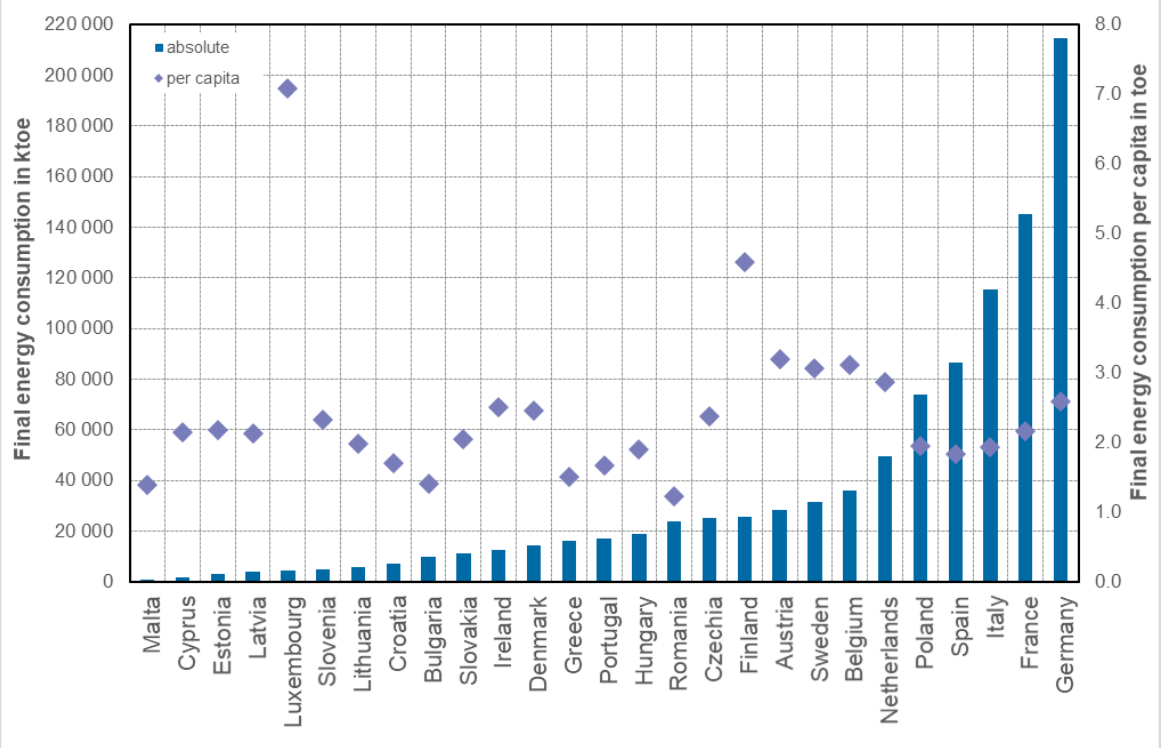
In the following we show PEC and FEC for all EU MS for the year 2019 in absolute terms and per capita. Germany has the highest absolute PEC and FEC in the EU, Luxembourg the highest per capita PEC and FEC.

Figure 9: Primary energy consumption absolute and per capita, per country for 2019



Source: own representation based on Eurostat 2022

Figure 10: Final energy consumption absolute and per capita, per country for 2019



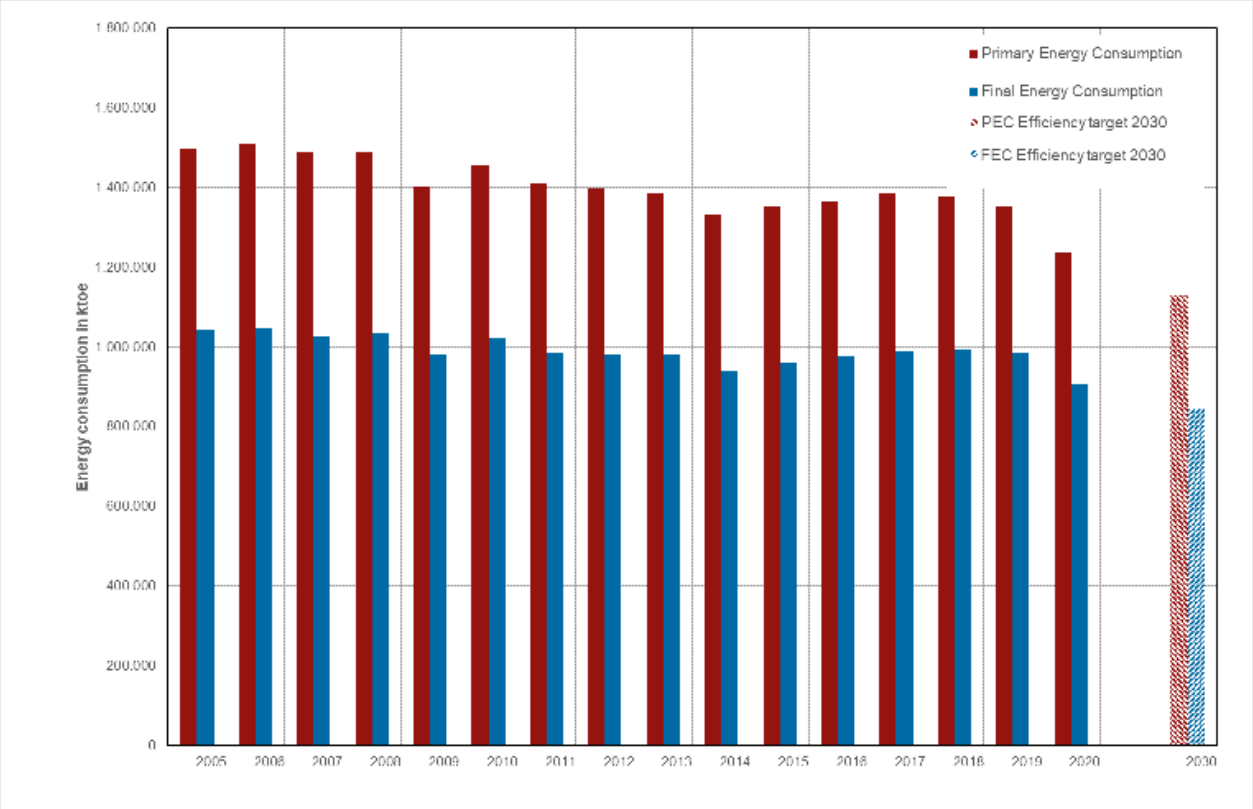
Source: own representation based on Eurostat 2022

Figure 11 shows the historical development of PEC and FEC of EU27 (aggregated) and compares it to the current legislatively set but non-binding targets for 2030. The absolute targets were introduced with the 2018 EED and amount to 1,128 Mtoe (PEC) 846 Mtoe (FEC).

PEC ranges between 1,500 Mtoe (2005) and 1,350 Mtoe (2019), FEC ranges between 1,040 Mtoe (2005) and 990 Mtoe (2019). In 2020, the consumption was lowered due to the Covid-19 pandemic, so this last year has little significance. Translated into per capita figures, PEC ranges between 3.5 and 3 toe/pc, FEC ranges between 2.4 and 2.1 toe/pc (not shown in the figure).

So, for both PEC and FEC there has been a decline: -10 % for PEC and -5 % for FEC between 2005 and 2019. To reach the targets in 2030, a much stronger reduction path is needed for the coming few years, however.

Figure 11: Primary and final energy consumption for EU 27 aggregated, absolute for 2005-2020 and 2030 targets



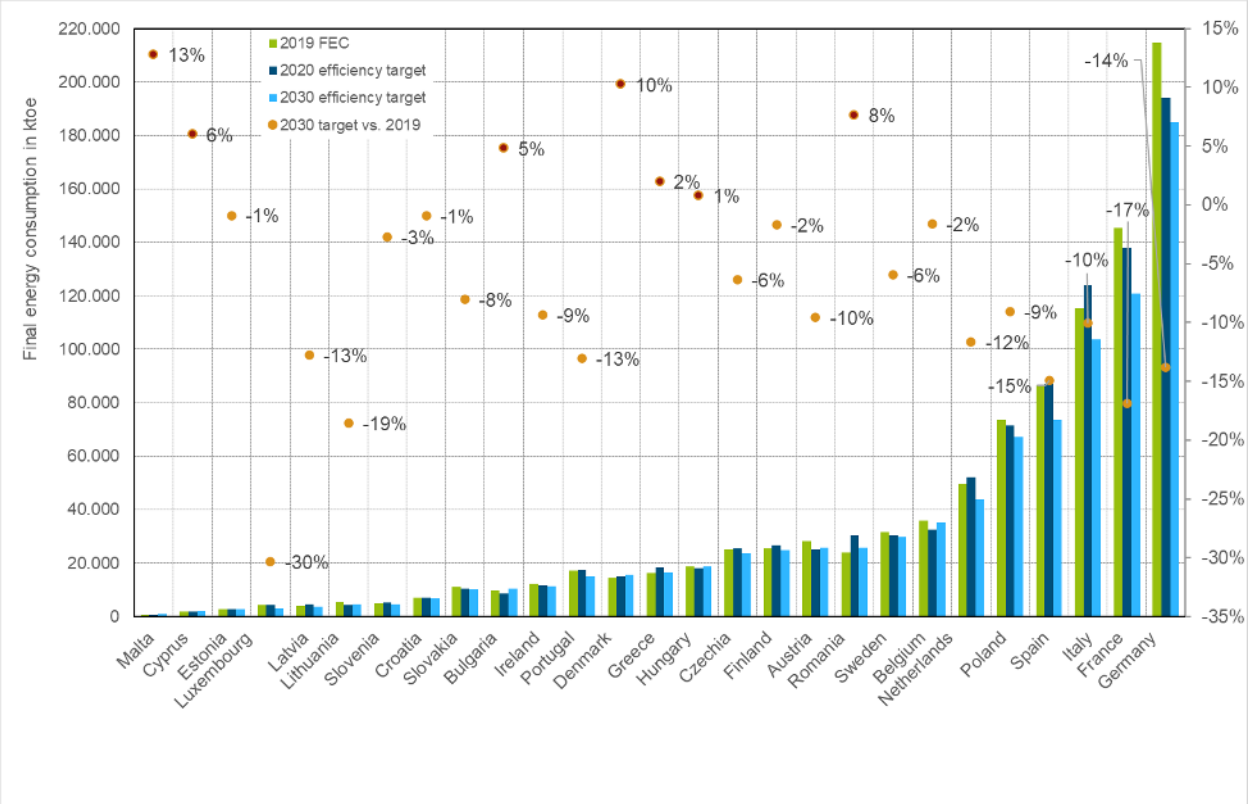
Source: own representation based on Eurostat 2022 and EEA [19]

As sufficiency focuses on a reduction of activity levels, FEC is the important indicator. Thus, we will have a closer look at FEC in the following. To reach the EU FEC target, MS made contributions on their FEC reduction for 2020 and also for 2030 as part of their NECP, see blue bars in Figure 12. Compared to 2019 (green bars), the relative contribution of Luxembourg with -30% is highest (orange dots mark relative reductions). It can, however, also be seen, that some countries plan to increase their FEC by 2030 compared to 2019 (red dots). Highest increases are planned in Malta (+13 %) and Denmark (+10 %).

[19] https://www.eea.europa.eu/ims/primary-and-final-energy-consumption

The 2020 targets were reached mainly due to the Covid-19 pandemic, reports from the EEA[20] and the EU Commission state[21].

Figure 12: EU-27 Member State contributions to the FEC efficiency targets for 2020 and 2030



Source: own representation based on EEA indicator on FEC and PEC[22], NECPs as reported in 2020[23]

Note: Orange dots are MS contributions to the FEC target aiming at a FEC reduction. Red dots are contributions aiming at a FEC increase.

There is an ongoing discussion about higher energy efficiency targets at the EU level at the moment. The Commission proposed a FEC reduction to 787 Mtoe in 2030 in July 2021 (this would mean a 9 % reduction in 2030 compared to the projections of the 2020 Reference Scenario) and revised their proposal to reach a level of 750 Mtoe in 2030 in May 2022 (this would mean a 13 % reduction)[24]. The European Parliament even voted for a reduction of 14.5 % in September 2022[25].

A recent study by Cambridge Econometrics (Alexandri et al. 2022) analysed the benefits of an increased energy efficiency (FEC) target of the EU and found that in 2030, the 14.5 % target would save the EU households 120 billion Euros on energy and transport bills (compared to 84 billion Euros with the 9 % target), would save the EU 38 billion Euros in fossil fuel imports (compared to 28 billion Euros with the 9 % target), would lead to 12.2 % greenhouse gas emissions reduction (instead of 8.1 % with the 9 % target) and would create 752,000 jobs (compared to 548,000 with the 9 % target).

[20] https://www.eea.europa.eu//publications/trends-and-projections-in-europe-2022
[21] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0641&from=EN
[22] https://www.eea.europa.eu/ims/primary-and-final-energy-consumption
[23] https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en
[24] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-targets_en
[25] https://www.euractiv.com/section/energy/news/eu-parliament-groups-unite-behind-14-5-energy-savings-goal-for-2030/

The study suggests the EU to even set the target higher, e.g. to 19 %, to multiply the benefits once more. This follows the EP proposal (2021/0203) (European Parliament (EP) 2022) for which the European Commission (European Commission (EC) 2022) already did modelling cycles to assess its impact. In this modelling exercise it becomes obvious that an increased ambition in FEC reduction does not decrease PEC in the same way: If FEC reductions are gained via strong electrification trends and if these higher electricity needs are not reflected in adequately higher renewable energy supply, there is an increased demand on fossil fuels in the energy industry sector. Obviously, if activity levels are not reduced, FEC can only be lowered via increased energy efficiency and electrification which could then lead to a GHG backfire effect. **It could be further investigated if the idea of sufficiency / lower activity levels is reflected in the modelling of the European Commission.**

What is clear is that the EU needs to monitor MS progress on FEC reduction to see if it is on track. Data sources are Eurostat, NECPRs and updated NECPs. MS GHG projections reports could also include energy information, but only few contain it.

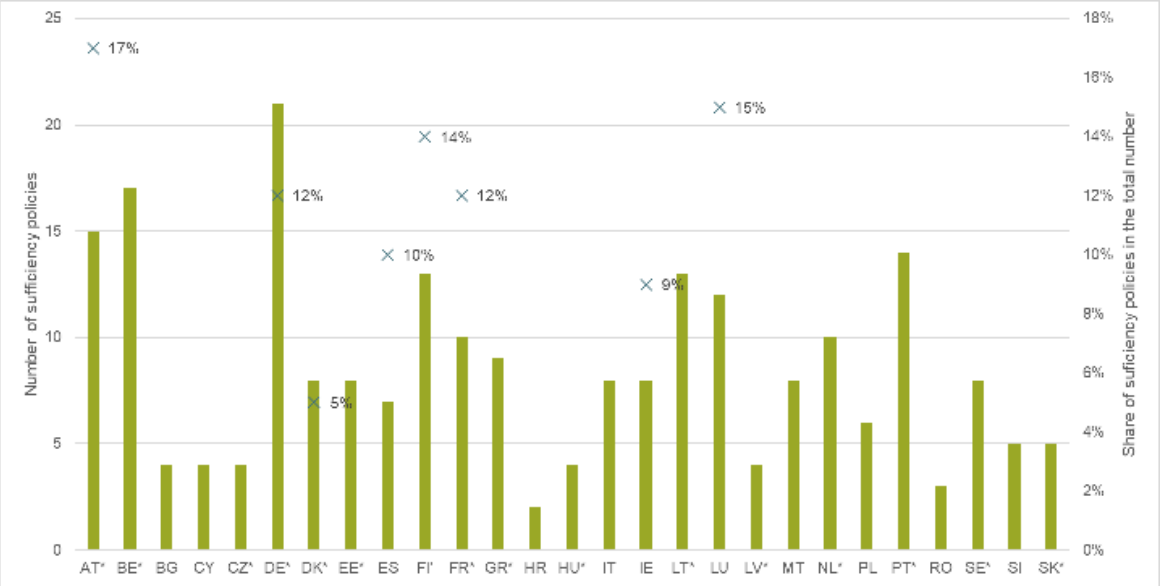
6 Analysis of the status quo: The role of energy sufficiency in the EU strategies and its processes

6.1 The role in NECPs and LTS (first final versions of 2019/2020)

In 2020 /2021 a team of researchers analysed the first final versions of the MS NECPs and LTSs, which were due by the end of 2019 (NECPs) and the beginning of 2020 (LTSs), on the topic of sufficiency. There, a broad understanding of sufficiency was used as described in chapter 1 and Table 1. The results are published in a scientific paper, see Zell-Ziegler et al. (2021). The main outcomes are that the term “sufficiency” (or the equivalent in national language) does not occur very often (French LTS 17 times, French NECP 4 times, Austrian LTS once, German NECP once, not found in documents of the other countries) and that the number of identified sufficiency policies is rather low (from a minimum of 2 in the Croatian document up to a maximum of 22 in the German documents), see green bars in Figure 13. Here we can also see that some countries like Germany do not use the term sufficiency but have quite some policies about it and that e.g. France has less policies on sufficiency than mentions of the term (a lot was found in the strategic/visionary part before the policy part).

In a follow-up analysis, which is not published yet, the same research team has determined the share of sufficiency policies in the total number of mitigation policies in the NECPs of eight countries. The outcome is that the shares range between 5 % (Demark) and 17 % (Austria), see blue crosses in Figure 13. In conclusion, sufficiency does not play a very important role in the NECPs/LTSs.

Figure 13: Sufficiency in NECPs and LTSs of EU MS: number and share of policies

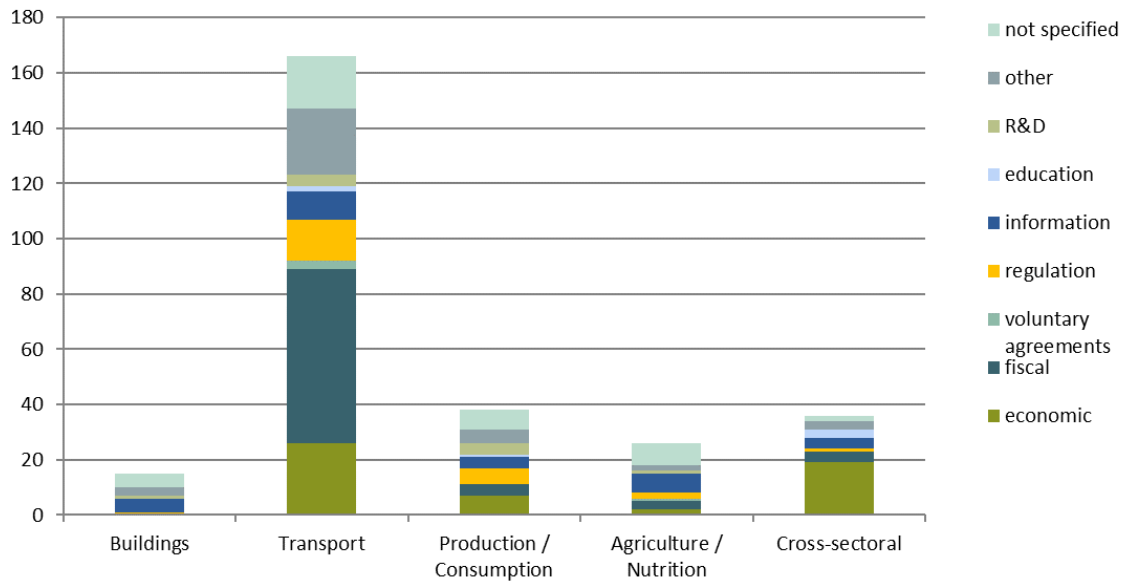


Source: Data from Zell-Ziegler et al. (2021) and follow-up research by the same research team (Lage et al., not yet published), own representation.

Note: * means that for those countries an NECP as well as an LTS was analysed (for some countries there was no LTS available for analysis because they were handed in some months later than the official deadline)

The analysis showed that most of the sufficiency policies (almost 60 %) can be found in the transport sector and least of them in the buildings sector (5 %), see Figure 14. The policies in the transport sector mainly aim at modal shift.

Figure 14: Sectors and instrument types of sufficiency policies in NECPs/LTSs



Source: data from Zell-Ziegler et al. (2021), own representation. Instrument type categorisation from UNFCCC (2000)

The policies have also been categorised by instrument type according to UNFCCC (2000). More than a quarter of them are fiscal ones and they occur mainly in the transport sector. A commonly found example in the reports is a state investment in rail or cycling infrastructure. The main instrument type of the cross-sectoral policies is economic, so mainly CO_2 or carbon taxes. In all sectors policies were found which could not be categorised because they were not specified enough in the reports. Policies categorised as "other" are mainly action plans the countries want or are about to develop and policies on digitalisation which could support more sufficiency.

6.2 The role in other processes/legislation

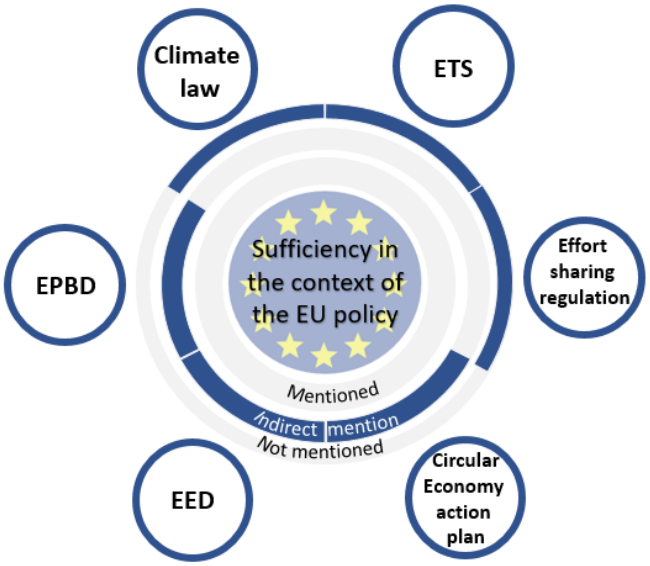
During the last years, European policy has mainly focussed on the energy efficiency first principle (EEF). The EEF currently mainly aims at optimising the electricity generation or lower fuel input in industrial processes in the EU while taking full account of security of supply[26]. As exposed in this work, not overconsuming energy is not only complementary to energy efficiency but necessary to achieve the climate and sustainability targets. Nevertheless, most of the EU schemes do not directly address sufficiency or do not address it at all (Figure 15). For example, the Circular Economy (CE) action plan 2020[27] mentions the concept of "social economy", which stands for the reuse and value maximization of the materials inserted in the production-consumption chain, hence theorising the existence of a maximum of resources required for the production chain to run. Yet, it does not directly address sufficiency. The EU Ecodesign Directive[28] and the proposal for a Sustainable Product Regulation[29] are related to CE (and therefore not mentioned separately in Figure 15) and focus on circularity and energy performance, so consistency and efficiency at the moment. The commitments

[26] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-first-principle_en
[27] https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF
[28] https://single-market-economy.ec.europa.eu/single-market/european-standards/harmonised-standards/ecodesign_en
[29] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products_en

listed in the Fitfor55[30] show the intention to engage in policies backing up the purpose of sufficiency such as the increased energy efficiency targets but do not account any specifics. The EPBD legislation[31] already makes references to strategies linked to sufficiency such as the importance to manage actively the energy demand of the built environment or the need to establish standards for energy use associated to the different building types. In the current process of recasting the directive, the European Parliament adopted a text in March 2023[32] that mentions sufficiency eleven times, including a definition based on the IPCC's (see chapter 1) and states that it is an important strategy for decarbonising the building stock. The Trilogue will show if sufficiency stays in the text.

Similarly, in its purpose to endorse efficiency, the amended 2018 EED acknowledges the need to address direct energy savings by considering consumption trends and consumer behaviours ("Member States shall have regard to how energy use and demand would evolve… by taking into account at least the following factors: energy consumption trends, changes in consumer behaviour, technological progress and changes caused by other measures implemented at Union and national level") but the scheme fails to address the issue concretely.

Figure 15: Overview of some EU policies in relation to their consideration of sufficiency principles



Source: own representation

Other regulations or schemes completely fail to refer to the concept, even indirectly. For example, the ETS[33] directive establishes a system of emission allowances for the installations engaged in a production system with the aim to reduce GHG emissions gradually. However, it doesn't consider or imply maximum or limitations to production to match real needs. Similarly, the Climate law[34] regulation refers to concepts such as the cost-effectiveness and economy efficiency or the need to ensure a just and fair transition but doesn't include any concrete details. The Effort sharing regulation[35] proposes annual emission allocation for the different MS to match 2030 GHG targets

[30] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/
[31] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF
[32] https://www.europarl.europa.eu/doceo/document/TA-9-2023-0068_EN.html
[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:02003L0087-20180408
[34] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119&from=EN
[35] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020D2126&from=EN

but fails as well to link them with decrease in consumption or consumption maximums. From a wider perspective, the EU Green Deal introduces objectives to promote ambitious energy savings in the building and transport domains but did not include mentions for instance, to the possibility to fix and/or reduce consumption standards.

The reason behind these observations might lie on the public perception of sufficiency as a radical imposition to limit the use of resources. Any limitation to the access to services (sufficiency) might collide with cultural norms, individual and collective habits, or lifestyle changes, eventually prompting "social resistance" and failing to attain its objectives (IPCC 2022). This conception contrasts sharply with the conceptualisation of sufficiency exposed in this work, in which sufficiency is rather understood as a responsible and sober use of resources.

Moreover, the inclusion of the concept in climate and economical legislation offers rather positive outcomes. That is the case for example of thermal refurbishment measures addressing energy poor households. Inhabitants in energy poverty are often in situations of underconsumption that put them in precarious living conditions (Sunikka-Blank und Galvin 2012). Relying on the sufficiency principle here allows to highlight the need to accelerate the renovation of these households so they can benefit more from energy services, that might include increased consumptions. The EU project streamSAVE identifies and proposes energy savings calculations that consider these differences[36]. On the opposite, a recent review identified situations in which the increased use of energy does not come along with improvements in wellbeing (Burke 2020), showing that sufficiency thresholds could be used as an indicative mechanism to identify overuse or underuse of resources. **Future research should assess the benefits and drawbacks (e.g. distributional effects) of policies relying on sufficiency mechanisms.**

6.3 European Citizens' Panel on Climate Change

Besides official political strategies like the NECPs or LTSs and other legislation, another approach of policymaking and political legitimisation are citizen panels /citizen assemblies.

The Conference on the Future of Europe, commissioned by the European Commission, included a European Citizens' Panel on "Climate change and the environment / Health" as one of four panels (Conference on the Future of Europe 2022). Randomly selected 200 citizens of all EU MS met in 2021/2022 to work on recommendations on the topic, about 50 of the recommendations were supported by at least 70 % of the citizens and hence found their way into the outcomes document (Conference on the Future of Europe, 2022).

Using the same method as for the NECP/LTS analysis (see chapter 6.1) we counted that 25 of the recommendations – so about 50% of the total recommendations – can be assigned to sufficiency. This is a significantly higher share than found in the NECPs of eight EU MS, see chapter 6.1.

Most policies (9) can again be found in the transport sector and least (1) in the buildings sector. We list all found sufficiency policies in Table 3.

[36] https://streamsave.eu

Table 3: Sufficiency policies in the recommendations of the European Citizens' Panel on Climate Change

Sector	Description of policy	Instrument type
Mobility	develop a European public transportation network, improve connectivity of rural areas	fiscal
Mobility	improve existing transport infrastructure, build more railway	fiscal
Mobility	incentives for public transportation usage (incl. internet connectivity, short & realistic time frames)	fiscal
Mobility	investment in new bike lanes and improvement of existing ones	fiscal
Mobility	widely available training on road traffic rules for all age groups across Europe, especially for e-bikes and for those without drivers' licenses to make cycling safer	information
Mobility	legal protection to and better insurance of cyclists, priority and further rights to cyclists and pedestrians over MIT (like in the Netherlands)	regulation
Mobility	dedicated car-free zones in cities	regulation
Mobility	subsidies for farms with short supply chains	fiscal
Mobility	establish a legal framework to ensure affordable, and better access to local and quality food products -> increase local food structures, reduce transport emissions	regulation
Production / Consumption	unified labelling system showing the ecological footprint of all products purchased in the EU (products from outside the EU need to respect this labelling system in a transparent manner)	regulation
Production / Consumption	the EU should combat planned obsolescence by lengthening products' warranty	regulation
Production / Consumption	setting a maximum price for spare parts after the warranty period	regulation
Production / Consumption	all member states should introduce a tax break on repair services as is the case in Sweden	fiscal
Production / Consumption	manufacturers should be required to declare the expected lifespan of their products.	regulation
Production / Consumption	the EU should provide information on how to re-use and repair products	information
Production / Consumption	Products with a low sustainability score should have a mandatory disclaimer in all forms of advertising that shows that they are harmful for the environment. For products that are not sustainable at all the EU should ban advertising.	regulation
Agriculture / Nutrition	Common Agricultural Policy (CAP) reform: redirection of the generic subsidies for agriculture mainly towards projects related to the development of sustainable agriculture and more sustainable and locally based agriculture; better monitoring of the ecological impacts of agriculture.	fiscal
Agriculture / Nutrition	common norms for animal farming (e.g. maximum number of animals, appropriate outside space)	regulation

Sector	Description of policy	Instrument type
Agriculture / Nutrition	stronger investment into non-intensive methods (extensive and sustainable farming) by providing financial incentives and training to farms	fiscal
Agriculture / Nutrition	tax on unhealthy food will lead to a diet shift away from GHG-intensive processed foods	economic
Agriculture / Nutrition	innovation in vertical farming to to save land space and allow for shorter supply chains	research and development
Agriculture / Nutrition	subsidise and support green spaces with gardening projects in cities, schools, buildings (instruments e.g.: The need for space, water and support infrastructure needs to be part of urban planning frameworks. There could be mandates to include green spaces for receiving building permits.) to support local agriculture and reduce transport emissions	fiscal, regulation
Cross-sectoral	We recommend the EU to set up a special website/platform verified by multiple experts -with regularly updated and diverse scientific environmental information- that is easily accessible and transparent to all citizens.	information
Cross-sectoral	streamlined information and training campaigns about the impacts of daily activities and other environmental topics across all EU states	information
Buildings	directive for greener cities and environmental urban planning, also meaning minimum standards for reduced energy consumption	regulation

Source: Extracts from Conference on the Future of Europe (2022)

7 Practical policies and their implementation

In this chapter we zoom into practical sufficiency policies and their implementation. At first, we interviewed Edouard Toulouse, an environmental engineer and sufficiency expert working for the négaWatt Association in France. France is quite advanced in the socio-political debate on sufficiency within Europe and has already a lot of scenarios explicitly considering sufficiency. We sent him five questions that he answered in writing.

In the second subchapter we elaborate on the individual carbon budget and various implementation possibilities as a possible solution. In the third subchapter we list some calculators that can be used to raise awareness as well as policies on responsible resource use with high potential.

7.1 Best practice for implementation of sufficiency policies, case of France

Question 1: How does it come the discourse in France on sufficiency is that advanced / widespread already? Is the topic and / or term also present in the wider public or more in professional circles?

Answer from Edouard Toulouse from négaWatt:

“It has been a long and gradual process.

Since the 70’s, criticising the excesses of capitalism and the consumption society has been vivid among French thinkers and a part of the civil society. Movements and philosophies challenging materialism, advertisement, or growth have had some successes.

Sufficiency plainly entered the energy policy arena in 2001 when the French négaWatt Association, a think-tank of energy experts and practitioners, published the first national energy transition scenario considering a reduction in energy consumption not only through efficiency but also sufficiency questioning the root causes of energy needs and usages (Association négaWatt 2018). From then, the concept of ‘*sobriété’* became increasingly popular in the public debate, although still triggering controversies and emotional rebukes. The négaWatt Scenario became a reference for most environmental NGOs and was actively promoted during public debates. Consequently, the word “sobriété“ entered legislation for the first time in 2015 as a goal of the national energy policy, although without concrete implementing measures at that time.

A few years later, the State added some sufficiency assumptions in the official scenario underpinning the French Long-Term Strategy for climate neutrality, after realising that the goal would be practically unachievable without. Those included behavioural changes in the residential sector, a moderation of the growth of mobility needs, a reduction of meat consumption, and efforts on circularity. The document qualified them as a ’reasoned’ consideration for sufficiency, indeed a rather careful and moderate step not entailing profound societal transformations (Toulouse 2020[37]). In a subsequent attempt at translating this scenario into more palpable terms, the Ministry of Environment co-produced with stakeholders’ illustrative narratives where sufficiency was highlighted as one of the 21 main themes and mentioned 50 times in the final report[38].

More recently, a stronger interest for sufficiency policies became noticeable. Many local authorities started promoting alternatives to cars in city centres, and moderation on artificial lighting. In 2020, a Citizen’s Convention on climate change established by the French President resulted in 150 policy

[37] Toulouse Edouard, 2020. La sobriété énergétique, une notion disruptive de plus en plus étudiée. *La Revue de l’Energie:* https://www.larevuedelenergie.com/la-sobriete-energetique-une-notion-disruptive-de-plus-en-plus-etudiee/

[38] Conseil national de la transition écologique, 2020. Vision de la France 2050: https://www.ecologie.gouv.fr/vision-france-2050

proposals, several of them sufficiency-oriented (restrictions on advertising, limits on urban sprawl, promotion of homeworking, ban of short-distance air travels, etc.)[39]. Some of them were (and are still) turned into law, albeit often with exemptions and reduced ambition.

A significant game changer took place at the end of 2021, during the campaign for national elections. Not only négaWatt but also other official bodies such as energy agency ADEME and power grid authority RTE for the first time published fully-fledged climate neutrality scenarios considering sufficiency as a viable option. This created a snowball effect and surge in media interest. After the publication, the number of occurrences of the keyword 'sobriété énergétique' more than doubled in French newspapers (source: Europresse database). These new scenarios reinforced the credibility of the concept, and share interesting similarities (Toulouse und Gaspard 2022). The impact was primarily visible on the energy policy debate, although it also seemed to reach the wider public. Just before the French Presidency of the Council of the EU in early 2022, a citizen's convention on the future of Europe has been organised in the country. When asked about the most important objectives for the continent, 100 randomly chosen French individuals have placed '*energy sufficiency to consume less and stop the superfluous*' as the top priority.

The Ukraine crisis only reinforced the trend. Faced with critical energy supply difficulties, the French government built its response strategy partly on stimulating immediate energy saving efforts, through an Energy Sufficiency Plan published in October 2022. Largely inspired by contributions from stakeholders such as négaWatt, the plan aims at saving 10% of the national final energy consumption within two years. Sufficiency has become a mainstream policy objective and the initial reluctances and caricatures have faded. The focus is now on the implementation challenges, and as the French President put it sufficiency is a 'need to organise our lives differently, (...) not only to solve the current energy crisis but also for the climate and our independence.' (Speech in July 2022).

In the last months of 2022, the media attention further increased, and many surveys have been published showing varying but mostly rising support of the population for sufficiency measures. Many other publications and initiatives are on their way."

Question 2: What are good implementation examples in France, can you describe the projects, the effects and who pushes it?

E.T.: "The list below mostly covers (national) policy decisions. Drawing a list of other sufficiency-oriented projects or local initiatives would be quite long. If needed, we could provide a few examples and point at other sources of information (but probably only in French).

- For 20 years, the city of Paris has had a constant and ambitious policy to reduce car traffic. Exemplary measures include car-free days, biking rental systems, cutting traffic on the banks of the Seine, developing bus, and cycling lanes, reducing speed limits, etc. The city now has a plan of becoming a '15-minute city', meaning improved accessibility to public services and activities to reduce the need for car trips.
- The French government has launched an Energy Sufficiency Plan in October 2022, involving many sectors, and supporting measures. Most are voluntary and there is little hard regulation, but the assessment of the low-hanging fruit potentials to cut energy waste is quite thorough (e.g. more reasonable heating and cooling temperatures, avoiding unnecessary ventilation, and lighting in tertiary buildings, etc.)

[39] https://www.conventioncitoyennepourleclimat.fr/en/

- A national Cycling Plan has been adopted in 2018, with € 350 million of investments, complemented by 150 million after COVID and another 250 million in 2022 with the aim to turn France into one of the leading cycling nations.
- A decision to ban domestic short-distance flights has been taken in 2021 and has received EU approval after harsh resistance from the industry. Trips that can be achieved in less than 2h30 by train can no longer be done by air. It covers a limited number of airlines but can be seen as a first step. In addition, the State has announced investments to reopen night train lines throughout the country that had been abandoned in the past.
- All schools in the country must offer at least one vegetarian lunch per week. By 2023, all cafeterias in public buildings (administrations, hospitals, universities, etc.) shall do the same. Municipalities are allowed to go further, as Paris will do.
- New commercial surfaces on virgin territories are not authorised anymore in the country, to reduce urban sprawl and support local shops (however, e-commerce warehouses have been exempted so far).
- As soon as 2012, a regulation has been passed to enforce the extinction of lights in office buildings and shops from 1 to 6 am. Poorly controlled and weakened by exemptions, the regulation has been reinforced in 2022.
- A number of decisions have been taken to reduce the use of plastics, packaging, and non-durable goods. Since 2022, manufacturers are not allowed anymore to destroy unsold products and shall donate or reuse them.
- Advertisements for fossil energies have been outlawed in 2022. By 2028, ads for conventional vehicles will follow. Indication of the carbon/energy labelling class is mandatory on publicities for cars and appliances."

Question 3: Who are the actors that push sufficiency at the moment?

E.T.: "After years of disdain by policy-makers and economic stakeholders, sufficiency has become more mainstream now. Under the national Energy Sufficiency Plan, all businesses have been called to prepare their own plan and appoint a sufficiency manager. Some companies have started advertising their commitments in shops, hotels, etc. However, it usually covers short-term easy measures and much less often more fundamental changes.

Across the political spectrum, most left and centre parties are supportive of sufficiency, although with political nuances related to social justice. The far right is more critical, considering sufficiency a way of blaming citizens for poor energy policy decisions."

Question 4: What role do NGOs play?

E.T.: "French NGOs have often expressed sympathy and interest for the sufficiency concept, although without capacity to really work on it. This has changed in 2022, with many leading green NGOs launching activities, communication campaigns and working groups on sufficiency."

Question 5: What role does sufficiency play in policymaking?

E.T.: "Although the roots were quite ancient, sufficiency has reached a significant momentum in the French policy-making arena in 2021 and 2022. This comes with obvious risks of greenwashing and confusion, and the tough decisions to foster long-term societal changes have not been considered yet. Some seeds have been planted, and the public debate has reached a new level as illustrated

by the media[40], citizen, and civil society interest. Examples of shocking energy waste and excessive lifestyles are increasingly named and shamed."

7.2 Individual carbon budget approach as solution?

Personal Carbon Budgets (PCB) are policy instruments that target the reduction of an individual's carbon consumption to meet a certain target, e.g. the 1.5°C target of the Paris Agreement. Thus, PCB have the same goal as sufficiency with an absolute reduction of emissions and consumption (even though sufficiency does not only focus on carbon and not only on overconsumption but also on basic needs). Even if there are many doubts and difficulties in implementation, it can be interesting to think about such instruments because in theory, they are very effective. Furthermore, the instrument can be designed to be socially very just if allowances are distributed equally without trading.

Two versions of PCB will be described and compared to the instruments Carbon Tax and Carbon Labelling in the following according to Brock et al. (2022). Table 4 summarizes the different instruments and provides their features and possible disadvantages.

Personal carbon trading

Personal carbon trading (PCT) is a cap and trade model: it sets a limit on emissions (for a country, area, or population) and allows for a market trading by buying and selling allowances that let consumers emit only a certain amount. This trading occurs in the form of a carbon credit that can be spent on goods or services. Those with higher incomes can have an advantage with this system as they can buy further credits, and hence have lifestyles of higher consumption. There are certain models in which there is a limit set as to how much an allowance may be traded (Haites 2018; Seyfang et al. 2007).

Personal carbon allowance

The Personal Carbon Allowance, PCA, is a scheme that is the same as the PCT except for the fact that there is no trading, thus, distribution methods of carbon, scope of emissions and other technical aspects are identical. The advantage of PCA is that it solves the social justice challenges present in PCT since it doesn't allow those who have the wealth for buying increased amounts of carbon credit over those with lower incomes to do so (Bristow et al. 2010; Fuso Nerini et al. 2021).

Carbon tax

The Carbon Tax (CT) is a policy that proposes a pricing on carbon, targeting to cut down the generation of carbon emissions by the public by taxing high-emitting goods and services. Germany, Canada, and Denmark, among others are countries that have already implemented CTs. The CT is applied proportionally to the carbon content of the fuel and it is applied upstream to the producer of the product, and therefore the prices of the goods or services increase if they used a carbon intensive fuel for their production (Sumner et al. 2009). CTs do not include caps on emissions and thus don't require goods and services to cut down their calculated footprints. The reduction on emissions with this scheme should be through the expectation that consumers would change their behaviours when confronted with higher priced items, due to the higher emission footprint (Goulder und Schein 2013).

Carbon labelling

[40] https://www.nouvelobs.com/ecologie/20220913.OBS63161/liberte-egalite-sobriete.html

The Carbon Labelling scheme is different to most measures as it is a voluntary one, in which goods and services would need to have a label on which the amount of carbon emissions is indicated, in regards of the good or service. Ideally, consumers would decide on a voluntary base on the carbon emission information whether they purchase or not the good or service. Therefore, it is a tool that assists consumers to make greener consumption choices (Marek et al. 2018; Upham et al. 2011). With this scheme, no enforcement on following the CL is engaged and there would be no emission caps present. CL relies on the idea that consumers' behaviours' can be changed and guided by providing information at the right time -the time of purchase. A number of brands and businesses have already implemented a type of CL especially by showing the kilograms of CO_2e per good or service, however in some cases the practice was discontinued to the costs of the labels (Brock et al. 2022). Additionally, as of now there are still no standards as to how to present the CL information and are currently dependent on the businesses themselves. Typically, a traffic light colour coding system has been used, in which red or black means heavy emitting product, amber average and green is better emission ratio (Vanclay et al. 2011).

Table 4 below based on Brock et al. (2022) presents a summary of the different instruments for carbon budgeting.

Table 4: Summary of the different instruments for carbon budgeting

Carbon Budget Instrument	Description	Disadvantages
Personal Carbon Trading	• Mandatory • Carbon 'credits' allocated per year, each credit worth a certain amount of carbon/value of carbon, additional credits have a cost. Surplus credits can be sold. • Allocation per person or household • Scope of what is included is variable but personal only • Requires goods and services' carbon footprint to be calculated • Credits could roll over to next year • Needs government body to regulate • Hard cap on emissions	• Trading may be socially unjust due to advantages those with greater finances may have • Requires considerable infrastructure • May be politically unpopular
Personal Carbon Allowance - No Trading	• Mandatory • Carbon 'credits' allocated per year, each credit worth a certain amount of carbon/value of carbon • Allocation per person or household • Scope of what is included is variable but personal only • Requires goods and services' carbon footprint calculated • Credits could roll over to next year • Needs government body to regulate • Hard cap on emissions • No trading of credits in any way	• Requires considerable infrastructure • May be politically unpopular
Carbon Tax	• Mandatory • Either flat tax or proportional to carbon emissions by weight per good or service • Levied upstream • Could have exemptions, etc. • No cap on emissions • Tax revenue could be invested in green enterprise and innovation	• No emissions cap means emissions generation cannot be limited to specific levels • Taxes largely politically unpopular • Regressive policy • • •
Carbon Labelling	• Voluntary • Responsibility all on companies to provide carbon information on products and services • Regulatory body not necessary • Requires goods and services' carbon footprint calculated • Public given target but no enforcement • May be politically popular due to being voluntary • No cap on emissions	• No emissions cap means emissions generation cannot be limited to specific levels • Cannot guarantee any reductions since it is voluntary

Source: based on Brock et al. (2022)

We did not find any implementation cases for PCT and PCA, just a report on a 4-week consumer trial in 2011 in London[41].

7.3 Calculators for raising awareness and policies on responsible resource use

The need to create indicative thresholds to guide responsible consumption is not new and a significant number of initiatives have addressed the issue in the past. From NGOs[42] to private[43] and public initiatives[44], there exist calculation methods to help individuals and communities[45] to calculate their impact and compare it to estimated optimums. These tools are merely indicative but offer good value to raise awareness about the overconsumption patterns that feature the life of people in developed countries.

An increasing number of policies are starting to consider intervention mechanisms to promote a responsible use of resources while creating at the same time new models and business opportunities. One of the most straight forward ready to implement scheme is the “right to repair” or “repairability index” recently adopted by the European Parliament[46].

This label will inform consumers on the capacity of a product to be repaired as has its maximum exponent in France (probably facilitated by the *sobriété* mindset), where it entered in place on the 1st of January 2021. This initiative is expected to facilitate the purchase of better-quality products, whose pieces can be dismounted and repaired if broken. The scheme also opens new opportunities to rescue the repair industry that has been fading into the limelight in the European economies as the throw-away economy has taken hold. The idea has been wining momentum and other national initiatives in the line are appearing, such as the *Förderaktion Reparaturbonus* in Austria. The reparability index is a good example to illustrate how the individual engagement in the smart use of resources (consumption pattern shift from more long-lasting products) needs to be followed by favourable policies. An independent report estimates in 20 % and 60 % the share of CO_2 reductions that can be avoided by individuals and collective action respectively[47]. Legislation changes such as the *Ley General para la Defensa de los Consumidores y Usuries’ (TRLGDCU)* in Spain, which aims to increase the product’s warranty duration from 2 to 3 years, is another good example of legal support mechanism that follows sufficiency behaviour.

[41] https://ctprodstorageaccountp.blob.core.windows.net/prod-drupal-files/documents/resource/public/Personal%20Carbon%20Allowances%20White%20Paper%20-%20REPORT.pdf
[42] https://footprint.wwf.org.uk/#/
[43] Etiquette de performance énergétique comportementale - https://www.economiedenergie.fr
[44] https://epale.ec.europa.eu/en/resource-centre/content/footprint-calculator
[45] https://www.climatealliance.org/activities/tools-and-methods/carbon-calculator.html
[46] https://www.europarl.europa.eu/doceo/document/E-9-2021-001461_EN.html
[47] https://www.carbone4.com/publication-faire-sa-part

8 Recommendations

From what has been discussed in this paper we developed some recommendations for the inclusion of sufficiency into EU or national processes and policymaking. They revolve around the topics (subchapters) knowledge / visualisation, EU processes, data analysis/sufficiency indicators, consumption corridors and research.

8.1 Increase knowledge on the concept and visualise it

The concept of sufficiency, its benefits and potential are not particularly well known to many. There should be more information on the topic available to the broader public. Implementation examples like the ones presented in this report could be portrayed to connect the concept with real life.

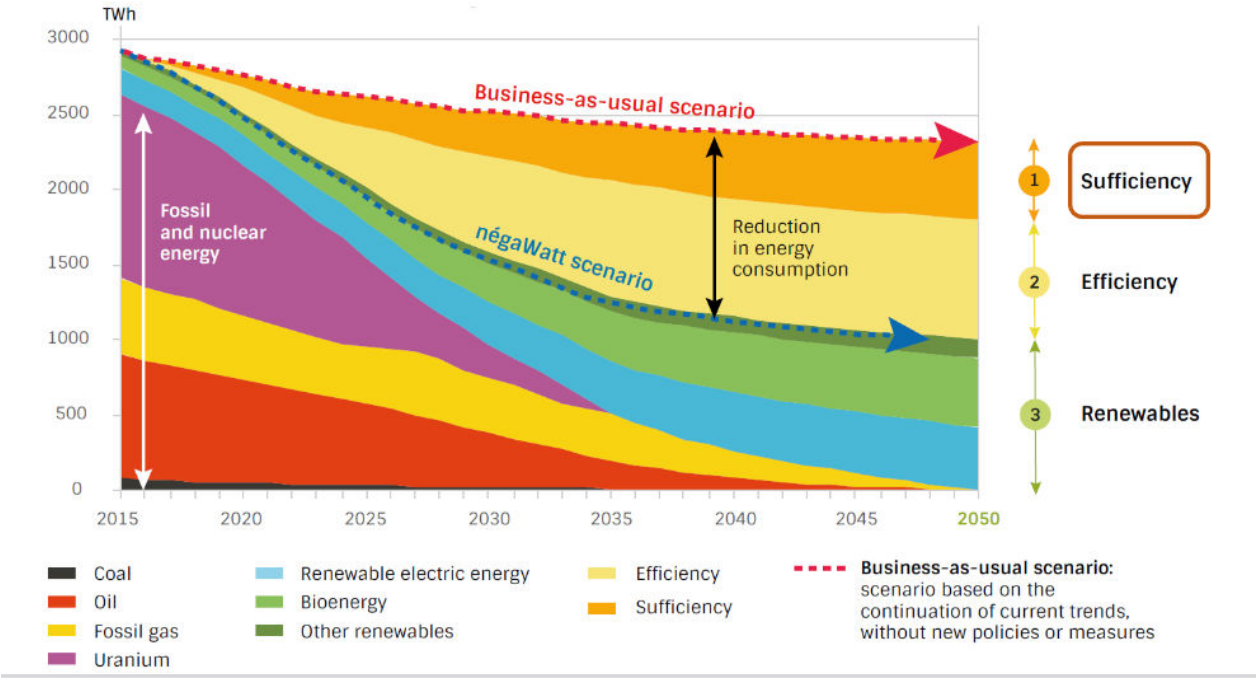
For professional circles working in the topics of energy and climate protection, webinars could be a good format to present the topic, answer questions and think about how it can be integrated into the work of the participants. The webinar could be structured similarly to this paper and include

- definitions and explanations of the concept
- description of the necessity and the multiple benefits
- levels and actors addressed by sufficiency
- mitigation potentials
- depending on the target group…
  - analysis of data on EU and MS level to see historical developments and projections on energy demand and activity levels
  - suggestions for policy instruments
  - implementation examples
  - analysis of success factors
  - …

The goal of the webinar would be to establish sufficiency as a strategy for the EU and its MS so that they also consider it in their decarbonisation plans and modelling.

An example for visualisation of the contribution of sufficiency to decarbonization targets is shown in Figure 16. From the business-as-usual projection, sufficiency and efficiency reduce energy consumption. The remaining energy demand will be provided through renewable energies.

Figure 16: Visualisation example from the négaWatt scenario 2022



Source: Association négaWatt (2022a)

Another aspect in communication is the mentioned “carbon inequality” which should be addressed by appropriate word choice like “excessive consumption”, “overconsumption” or even “wastefulness” to make clear that the problem is not the average or even (energy) poor citizen. It is important to emphasise that we need sufficiency policy that gets to the root of the problem and the large emitters.

The sufficiency concept explicitly wants to ensure that the basic needs of all people are met, and this must be made clear when talking about sufficiency. In the CLEVER scenario (see chapter 4.2), they use the mechanism of “convergence” between European countries which means that e.g. living area can still increase in those countries where it is really low at the moment but needs to decrease in countries where it has exceeded a certain threshold. This justice approach seems very promising by anticipating conflicts over distribution. See also chapter 8.4 on a possible FEC corridor for Germany.

8.2 Existing EU processes where sufficiency should be integrated

In chapter 5.2 the current discussion on the energy efficiency targets has shortly been described. With the view of sufficiency, an ambitious reduction in energy consumption is necessary and possible, so an inclusion of sufficiency into the discussion could potentially support the argumentation on raising the ambition. In chapter 4.2 we showed FEC projections in ambitious scenario studies that demonstrate that a reduction of 50 % between 2020 and 2050 is possible.

As mentioned in chapter 5.2, it could be further investigated if the idea of sufficiency / lower activity levels is reflected in the modelling of the European Commission concerning e.g. the impact assessment of an increased FEC target (European Commission (EC) 2022).

As discussed in chapter 6.2, there are several important EU processes where sufficiency could play a role but where it is, until now, only mentioned indirectly: The EED, the EPBD and the Circular

Economy action plan. As sufficiency is a very holistic approach it seems to be crucial to bring people from different departments or DGs together and bring sufficiency forwards. Especially people working on energy / climate topics and people working on resource use should connect better. Also, in areas where sufficiency is not mentioned yet, like the Climate law, the ETS or the ESR as well as strategies for the protection of biodiversity, against soil sealing and land consumption, connections should be made to talk about sufficiency.

In the Conference on the Future of Europe, climate topics were merged with health topics and the citizens came up with a lot of sufficiency- and non-sufficiency-related policy recommendations. Following up on this interlinkage also seems promising because it draws on the multiple benefits that sufficiency policy can have.

8.3 Data analysis and useful indicators

At the moment, the EU and MS mainly track and project emission development, data on energy consumption is already harder to find (especially projections) and activity data, which mainly links to sufficiency, is very hard to find. There are databases like ODYSEE-MURE[48] and ENERDATA[49] which contain historic data on some of the activity data, but projections are rare.

However, there are EU obligations for MS to hand in projection data on FEC (projection reports). These should be analysed and monitored as well as the PaMs which MS deliver with the projection reports to see where MS already aim at an absolute reduction of energy or resource use and activity levels.

As mentioned before, when looking at data that give a hint on sufficiency, especially activity data on energy-consuming services make sense as well as final energy consumption. To track progress of sufficiency it makes sense to define sufficiency indicators which can be monitored.

In his master's thesis, Vogel (2022) distinguishes sufficiency indicators into input and output indicators. Output indicators are those that measure how we live, travel etc. like floor space per capita, meat consumption per week or travelled distance by car in a year. Input indicators shed a light on the system we live in, e.g. distance to nearest bus stop or frequency of public transport, offer of vegetarian and vegan dishes in canteens and so on.

Also here, MS are already asked to deliver indicators and data with their projection reports and other reporting obligations, however, we had a look at the delivered data and found that reporting is rare. So, where indicators are already included in the reporting templates, but reporting is rare, MS should be motivated to really report these values (e.g. in Table 3 for reporting on Article 38 on national projections under Article 18 of the Governance Regulation). There are already a lot of interesting indicators like FEC by sector and data on underlying drivers like household size (inhabitants/household), number of passenger-kilometres (million pkm) and freight transport tonnes-kilometres (million tkm) but only a handful of MS currently report on these indicators.

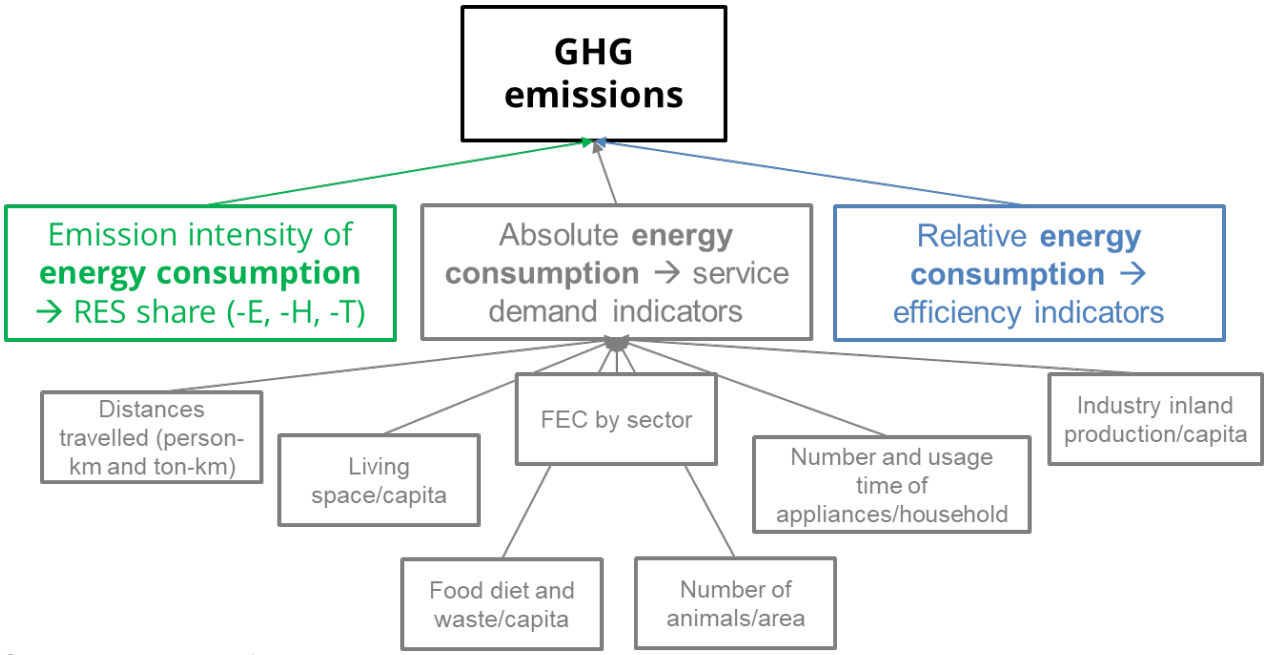
As a next step, the EU should include more indicators – input and output ones – in their reporting obligations e.g. for NECPs, NECPRs and LTSs and motivate MS to hand them in for monitoring.

Possible additional indicators per sector could be (see also Figure 17, much more are possible and make sense):

[48] https://www.indicators.odyssee-mure.eu/
[49] https://www.enerdata.net

- Buildings: Living space/capita & energy needed for heating (in m²/capita & TWh)
- Transport: number of passenger-kilometres of active modes of mobility (bike and foot), frequency of public transport, weight of cars, number of ton-kilometres for freight
- Industry: Total inland production (in tonnes/capita or /GDP), average warranty time for appliances, steel input per building
- Agriculture: number of animals/area & consumption of animal products (g/week)
- Consumption: number of appliances per household, usage time of appliances, water use/capita

Figure 17: Cascade of indicators from emissions to energy consumption to service demand with possible indicators



Source: own representation

Furthermore, on a meta level, it would be great to get to know more about the MS modelling assumptions and procedures: E.g. are activities modelled via policies and measures or via GDP development or differently?

8.4 Proposal for consumption corridors for EU MS

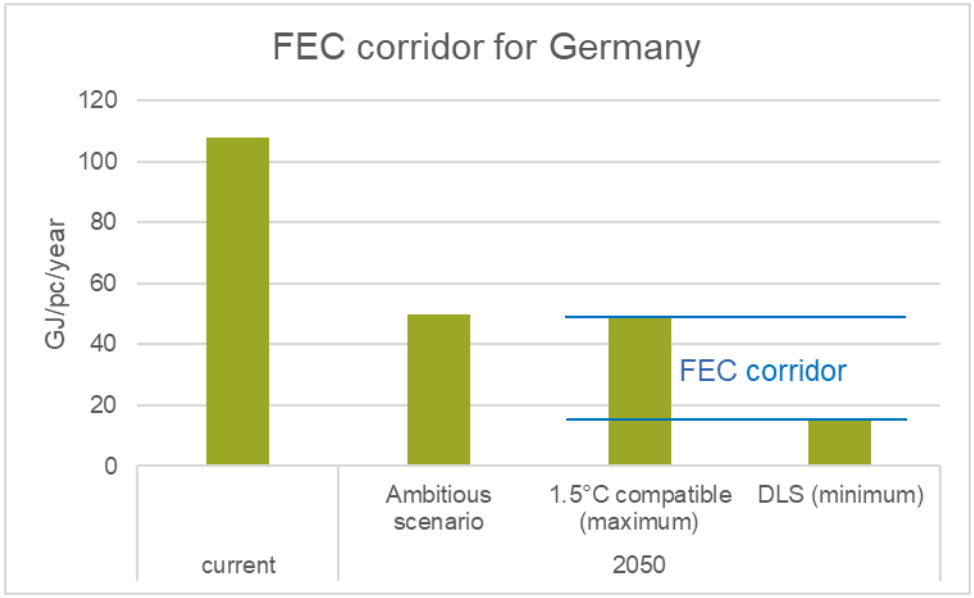
In chapter 1.1 the concept of consumption corridors was introduced and in chapter 4.2 the CLEVER scenario was presented. This scenario implemented consumption corridors for several indicators, e.g. for per capita floor area (Taillard et al. 2022). A corridor between 32 and 40 m²/pc for countries where floor area was below 40 m²/pc in 2015 was defined. For countries with higher per capita floor area the value for 2050 was not allowed to exceed that of 2015. Important was the convergence between countries, so a reduction of historically overconsuming countries and an increase of historically "underconsuming" countries.

Another example for a consumption corridor is presented in chapter 2.4 on the just energy transition. As was shown, there is literature that can be used to define such corridors, not only for the past but also for the future: For minimum levels, e.g. decent living standards (DLS) can be used. There are energy-related studies giving those DLS also for activity levels (Millward-Hopkins et al. 2020; Rao

und Min 2018). For maximum levels, studies compatible with the 1.5°C target can be used, the most prominent is Grubler et al. (2018).

To illustrate this, we give an example for Germany and FEC in Figure 18.

Figure 18: Current FEC for Germany and possible consumption corridor



Source: Destatis, UBA (2020), Grubler et al. (2018) and Millward-Hopkins (2020), own representation

Note: Values for current and ambitious scenario are specific for Germany, 1.5°C compatible is for Global North and DLS value is a global one

The concept of consumption corridors and the implications for activity levels seems quite ambitious but is already anticipated by an ambitious scenario for Germany (UBA Green Supreme). The EEA or other EU players could start discussions on this and probably involve the project lead of the CLEVER scenario to discuss this approach with MS in more detail.

8.5 Increase research on sufficiency

As shown in the first part of the paper, mainly chapters 1 and 2, the sufficiency concept demands a more holistic view on the interdependent crises that we have (extensive resource needs and land consumption for decarbonisation options will lead to new problems e.g. for biodiversity). Hence, the focus needs to shift from looking at GHG emissions to energy use because an increasing demand for (even renewable) energy cannot be met without causing other environmental or even social problems. Integrating this multidimensional view more into energy and climate policy would be desirable.

An important step into this direction would be a more integrated modelling of climate, energy, and resource questions and in general more modelled decarbonisation pathways including sufficiency. Furthermore, the lifecycle approach, which also considers embedded emissions, should be strengthened in projections. To make the existing and newly calculated sufficiency potentials more visible and usable, a central database would be desirable.

It has, moreover, been emphasised that sufficiency is more than an individual consumer choice – it is also a policy field: Policymakers need to change framework conditions so that a less energy and

GHG consuming life is possible and desirable. Theoretical and practical policies and potentials of sufficiency (policies) are presented above. The good thing is: The proposed policies often do not need much technical innovation, so this strategy can be implemented rather fast and in a cost-effective manner (e.g. using the bike for distances < 2-5 km). IPCC (2022) shows that sufficiency policies are often cheaper than other policy options (figure 7[50] in the SPM of WG3 of AR6).

However, sufficiency is much about social innovation and demands a shift of mindsets and cultural factors away from our current consumerist and growth-dependent culture. So, when sufficiency becomes part of the political mainstream, there may be a deprivation of privileges of the upper and middle class and a questioning of the economic growth paradigm. There is definitely a need for more research on the effects of sufficiency policies like the decrease of energy consumption and activity levels on the economy, GDP, businesses, jobs, distributional effects and the financial and social systems we currently rely on. Concerning the design of effective policy instruments, important questions are how they can, on the one hand, reduce the large “carbon inequality” and especially reduce the environmental footprint of the rich and very rich people while on the other hand ensure that the poor members of society threatened by energy poverty are protected from the financial impacts of sufficiency policies.

We did not find any implementation cases for personal carbon trading and personal carbon allowances. Trials and small-scale implementation would be helpful to see if these concepts work and how they would need to be designed.

What makes it somewhat difficult to grasp sufficiency is that the concept ranges from small changes in routines to the adjustment of framework conditions to a major socio-economic transformation, see chapter 3. To assess which “level” of sufficiency is needed to reach our decarbonisation targets while ensuring socio-economic stability for all is not so clear yet. What is obvious, however, is that a low level of energy demand and GHG emissions should not only be an individual decision but needs political support.

In a report by Energy-SHIFTS, researchers from all over Europe formulated “100 Social Sciences and Humanities priority research questions for energy efficiency in Horizon Europe” (Foulds et al. 2020). This proposal for the Horizon funding programme includes 17 research questions that explicitly cover sufficiency. Furthermore, the topic of sufficiency was ranked as quite relevant in a survey they did (p. 29).

[50] https://www.ipcc.ch/report/ar6/wg3/figures/summary-for-policymakers/figure-spm-7/

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