SUSTAINABLE ECONOMY RESEARCH GROUP LGi

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Sufficiency as a mean to ease pressure on household budget: A quantified assessment on energy and material demand for French households

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1 Introduction

In a context where climate change effects are getting stronger and where reaching climate targets seems increasingly difficult given multiple geopolitical tensions, demand-side research is still underrepresented while it could offer low-hanging fruits to bridge the gap between emissions trends and carbon neutrality. Creutzig et al. [1] assess that demand-side may represent a huge, underexplored potential to reduce emissions – between 40% to 80% emissions cuts compared to a counterfactual scenario.

Low energy demand scenarios have emerged from Grubler's first LED scenario [2]. Research gaps are being identified through sectoral literature reviews [3] or cross-sectors database [4]. In the meantime, the scope has become larger, going from low energy demand to high well-being with low energy and materials demand in order to address planetary boundaries and environmental justice, however, there is still need for more interdisciplinary research [5]. Against this background, sufficiency as defined in IPCC 6th Assessment report addresses comprehensively these issues: "Sufficiency policies are a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being for all within planetary boundaries." [6]

Concretely, how can we model sufficiency and quantify its impact on the way toward carbon neutrality? Energy demand and material demand are embedded in the way we live [7]. Structural lifestyle changes resulting from considerations seemingly disconnected from environmental planning can lead to significant changes in energy consumption; lifestyle has to be considered as a step prior to energy demand in energy climate foresight studies [8]. However lifestyle does not only mean individual behavior [9]. "Behavior" refers to individual focus, while "daily practices" and "lifestyle" refer to social norms, notion of functioning as an organized group (neighborhood, territory, companies…). Several scales are at stake: individual, collective, institutional – the latter being crucial for energy and environmental policy.

This paper aims at defining a sufficient lifestyle to attempt actual quantification in energy and material demand. Applying this lifestyle to a household's energy and material consumption allows us to define concrete measures to carry out sufficiency, and to quantify the benefits for households in terms of savings. Despite data gaps and methodological difficulties, sufficiency modelling confronted with data on energy and material by households allows to quantify the actual impact of some of these measures.

2 Data and methodology

2.1 Data on energy and material consumption

This paper focuses on the main energy and material consumption of a French household. Average energy bill in 2023 is 3678 € per year per household, of which 1851 € for energy in housing and 1827 € for fuel. Energy represents 9,4% of household budget [10]. Beyond the direct energy bills, this energy consumption is associated with ownership of the corresponding equipment. A French household owns on average about one car, one of each major energy appliance (refrigerator, washing machine, TV…) [11] and possibly one heating device - depending on whether they own their home or rent it - which represents an expense every time they must replace such equipment.

We collect available data for energy consumption and/or corresponding activity levels for households related to energy consumption in housing and transport, as well as the main material demand. We also consider repercussions in all sectors as much as possible: building sector at large (not only residential

but also tertiary), rest of transport sector, and industry. While direct effects can be quantified, some effects are more indirect and diffuse, which would need a broader modelling effort to quantify. Here, we quantify only direct effect of the identified sufficiency measures. For indirect effects, that are more systemic or cross-sectoral, we make suggestions for modelling approaches that are out of the scope of this paper.

2.1.1 Data for main energy uses

Data for main energy uses is made available by the Statistical Data and Studies Department (SDES) of the Ministry of Ecological Transition. In the residential sector and the tertiary sector, main reported energy uses are heating, hot water, cooking, specific (lighting, appliances for cooling, washing, digital: TV, computers, smartphones and tablets) [12]. Although well present in the tertiary sector and bound to increase in years to come with climate change, cooling does not represent a significant energy use in the residential sector yet. Data is reported in annual consumption per household for residential and per m^2 for tertiary.

Regarding the transport sector, every decade, a large mobility survey is conducted by the SDES, which gives detailed information of motorization rate, modal share, trips and distances per household, per purpose…[13]. Here we focus on car ownership and activity levels per vehicle. A decomposition of vehicle mobility and associated distances in terms of how much for long distance, daily commute to work, to school, shopping, leisure, administrative… was produced by Bigo [14] on the previous survey.

All collected data is presented in the Supplementary material.

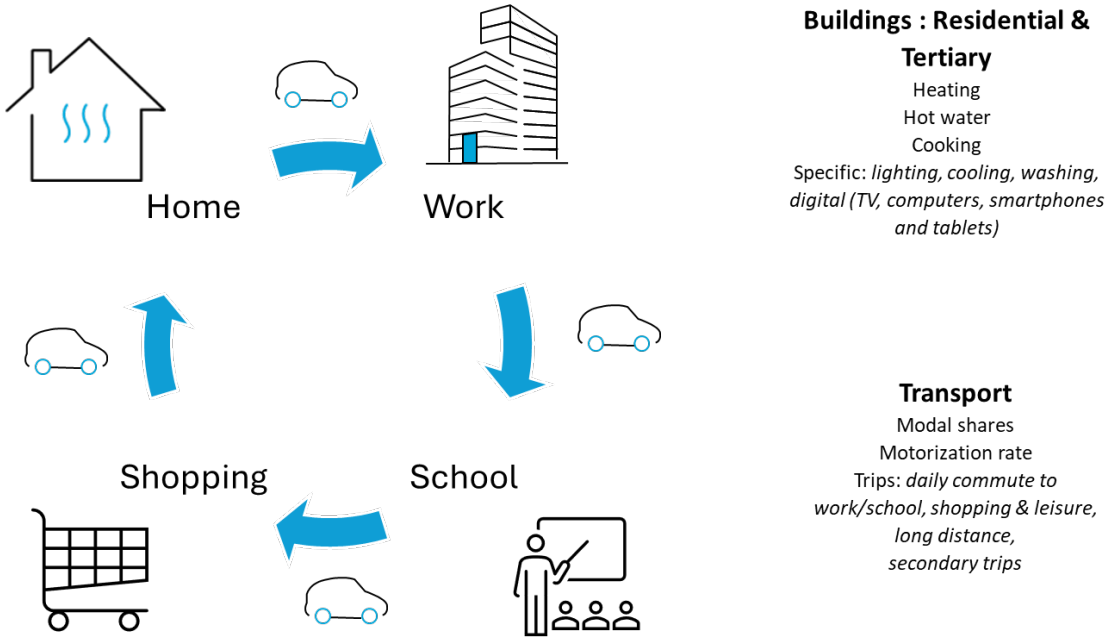


Figure 1: simplified representation of an average household member routine

2.1.2 Data for associated materials demand

The French Agency for Ecological Transition (ADEME) assessed the material demand for new builds [15]. They also provide data on vehicle weight and embedded materials. They project that between 2020 and 2050 the weight of an average thermal vehicle and an average electric vehicle, with associated materials [16]. Detailed data is presented in the Supplementary material.

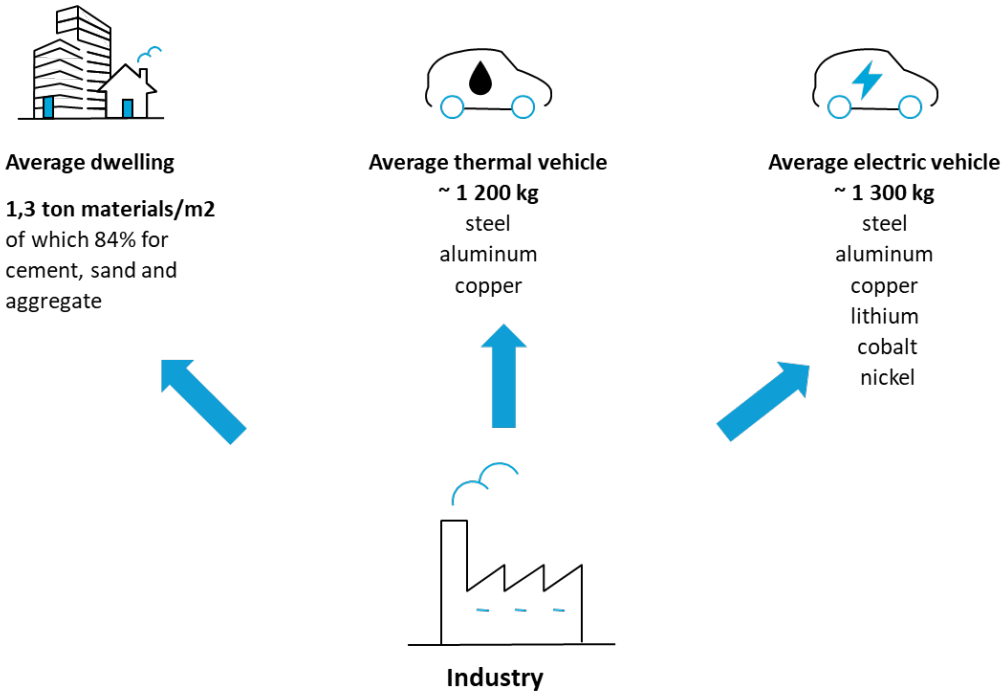


Figure 2: Embedded materials for construction and transport (cars)

2.2 Methodology: modelling a sufficient lifestyle

2.2.1 A modelling framework for sufficient lifestyles

Historically, most energy transition models have been largely focused on technological changes for climate mitigation, with limited attention to lifestyle changes and demand-side transformation [5]. The net-zero scenarios such as those included in the IEA Net Zero report, mainly relies on a fully decarbonized electricity mix completed with decarbonized fuels (biogas, hydrogen, alternative fuels), without consideration of major lifestyle changes [17]. Such a transition includes electrifying heating through heat pump or developing district heating, electrifying cooking or replacing gas by biogas, and electrifying individual transport as well. This transition pathway, if scaled up globally, will still consume significant amounts of materials and risk creating significant tensions in supply chains [18] or exceeding planetary boundaries [19].

In view of these observations, sufficiency explicitly defines a framework where planetary boundaries are protected, and tensions are defused by the generalization of well-being. Sufficiency scenarios or scenarios explicitly involving quantified sufficiency measures were exhaustively listed by Wiese et al. [4]: among them, the Negawatt scenario, the 'Frugality scenario' in ADEME study 'Transitions 2050', the sufficiency scenario in French TSO's study 'Energy pathways to 2050', the IEA Net Zero study. On the path to quantifying sufficiency, we found that these existing sufficiency scenarios include:
(1) Buildings: Implementing better sizing of equipment, promoting shared use of facilities, reducing average dwelling sizes, and adjusting indoor temperatures for moderation.
(2) Transport: Reducing highway speeds to optimize fuel economy, shifting long-haul flights to rail, and decreasing both total traveled distance and speed.
(3) Industry: Focusing on reduced material use and intensity during production.
(4) Food: Encouraging reduced meat consumption and implementing strategies to minimize food waste.

The impact of such measures on emissions were quantitatively assessed by Fontaine et al. [20] based on ADEME scenarios, showing that sufficiency measures can deliver up to 25% reduction in emissions. Although these sufficiency strategies are essential for modelling a sufficiency lifestyle, they mainly emphasize reduction efforts and do not confront considered measures with actual emerging trends in society. They also lack a comprehensive framework to guide various approaches for decreasing energy and material use. This oversight might neglect additional sufficiency measures like multifunctionality or circularity. To date, the paper by Zhang et al. [21] is one that offers such an exhaustive framework. DRUMSS framework clearly distinguishes between six key pillars of possible actions in support of energy sufficiency: Decentralization, Right-sizing, Utilization/Timing & Longevity, Multi-functionality, Substitution, and Sharing.

The DRUMSS framework was developed based on a comprehensive review of current sufficiency lifestyle modeling and other relevant frameworks, such as the '4D' framework (Decelerate, De-clutter, Decentralize, Decommercialize) by Wolfgang Sachs [22] ; 'Reduction, Substitution, and Adjustment' by Brischke et al. [23] and Stefan Thomas et al. [24]; 'Reducing, Substituting, Better Sizing, and Sharing' by Toulouse et al. [25]; and 'Absolute Reductions, Modal Shifts, Product Longevity, and Sharing Practices' as used by Sandberg [26]. These frameworks have inspired a re-evaluation of how to clearly delineate the boundaries among different sufficiency typologies while capturing the essence of sufficiency.

The existing frameworks mentioned above either fail to account for mitigation potential at the temporal level or spatial scale. Similarly, the ASI framework mixes elements of energy efficiency with sufficiency. The DRUMSS framework ensures that each sufficiency typology dimension is distinct from the others, as well as from efficiency, and is applicable in developing countries. For example, the concept of sufficiency emphasizes 'reduction,' but many low-income households in both developed and developing countries may not possess enough goods and services to meet the social foundation limit. To address this, DRUMSS uses the term ‘right-sizing,’ in addition to ‘reduction’.

In this framework [21]**, Decentralization** focuses on ‘localizing consumption’, which means buying locally produced seasonal foods, locally made goods rather than imported products, or choosing to travel for leisure locally rather than long-distance. **Right-sizing and reduction** means ‘choosing the appropriate size, amount, and usage of energy products/services’. Right-sizing reduces energy demand in cases of over-consumption while increasing it for under-consumption. **Utilization, timing, and longevity**: this axis searches for ways to extend longevity, like the operational lifespan of appliances, thanks to repairability of use of second hand-products. **Multifunctionality** refers to designs that furnish multiple services. Although the mode of delivery of energy services may be altered, the service is not. An example is digital convergence, such as a smartphone that replaces 17 or more devices, from alarm clocks to GPS. **Substitution** changes the mode in which an energy service is received. It includes modal shift to walking and cycling in the transportation sector for instance. It requires a change of norms, and thus public and societal support is needed, along with institutional and policy enablers. **Sharing**, involves utilizing a service or product to its full capacity through shared use, rather than individual ownership. Sharing actions exist across all consumption sectors, such as communal living and workspaces, appliance and tool sharing, carpooling or ride-sharing, and shared commercial kitchens.

Although more comprehensive than previously published frameworks such as ASI, the DRUMSS framework also presents some limitations. Zhang et al. [21] noted the six DRUMSS components can display interactions and interrelationships. For example, shifting to a plant-based diet could reflect both decentralization (more local produce) and substitution. Operationally, it is important to highlight the dependencies to avoid overcounting, but in practice, some linkages are difficult to quantify. For example, the right-sizing and reduction path could lengthen product longevity, whereas products having multifunctionality might experience greater utilization but potentially lower longevity. Similarly, sharing appliances may shorten their lifespan as they will be used more intensively, which would

contradict the “Utilization, timing and longevity” pillar - which does not mean that it not beneficial in terms of saving energy and resources. Overall, while not all interlinkages can be fully addressed due to the interconnected nature of our daily life aspects, sufficiency modelers can maintain clarity and transparency regarding these potential rebound effects.

2.2.2 Applying the sufficiency modelling framework to energy consumption and material consumption

We apply the DRUMSS framework to sectoral consumption trends from data and social science literature to identify concrete sufficiency measures from existing consumption trends, even if they are only weak signals (see Figure 3).

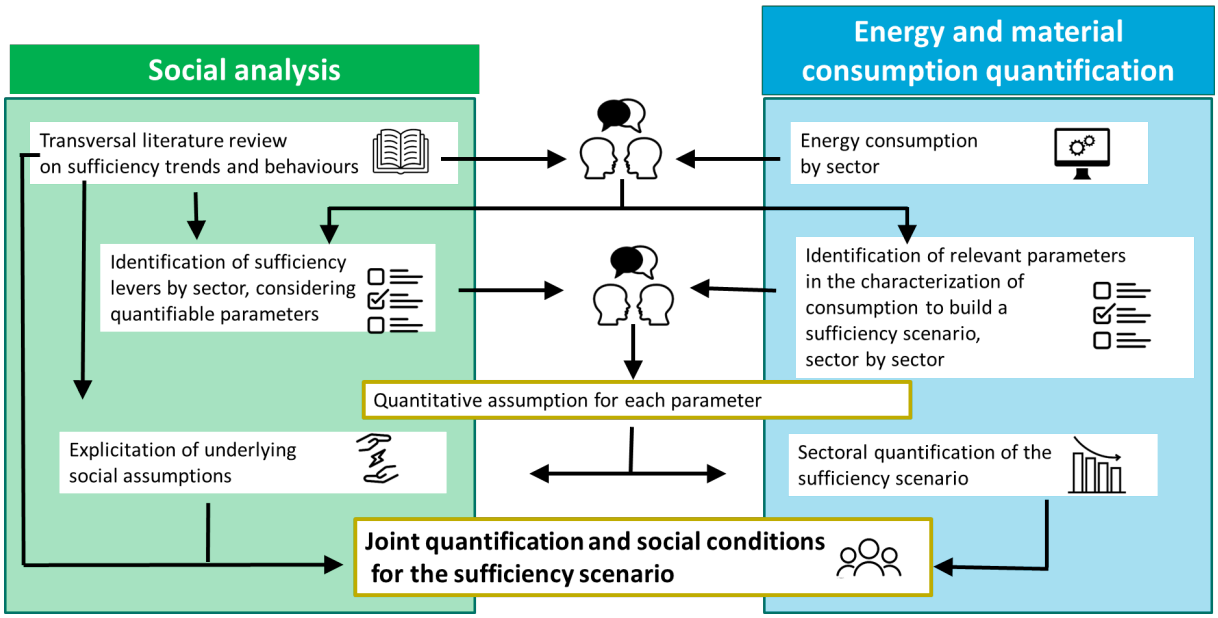


Figure 3 : methodology to identify quantified parameter corresponding to qualitative sufficiency pillars

Some measures carry out direct energy consumption reduction by themselves. Other measures imply consumption reduction in a more diffuse, systemic way, involving cross-sectoral effects and retroactions. Sometimes one measure can have both direct and indirect effects – an example is given in Figure 4. Whenever possible, a quantification method is elaborated. For measures that a likely to develop over a long period of time, we estimate the potential of deploying it by 2050. The energy or material reduction potential is expressed in percentage compared to a counterfactual

situation. To illustrate quantitatively, these reduction potentials are confronted with the latest energy consumption data per sector in the results section.

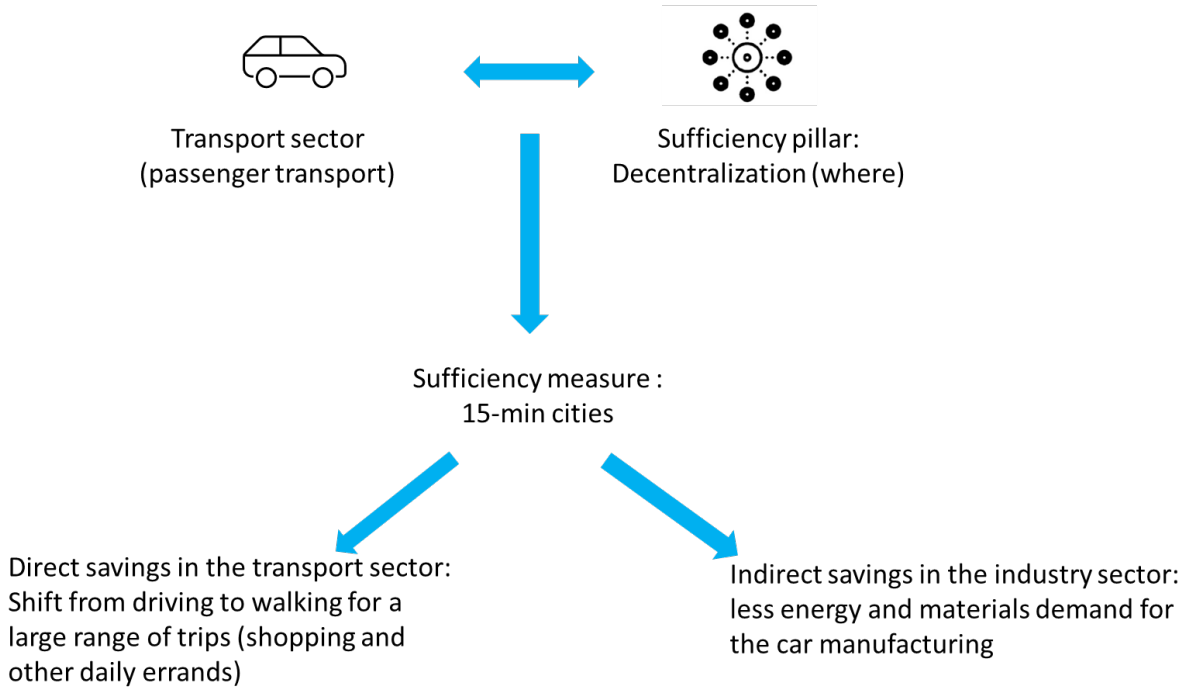


Figure 4: Deploying the method on one example of sector and sufficiency pillar

3 Results

3.1 Concrete sufficiency measures per sector from DRUMSS framework

This section presents the identified sufficiency measures from applying the DRUMSS framework to sectoral consumption trends from literature and observing weak signals in favor of sufficiency, whether from opinion surveys, emerging policy measures practices or emerging social practices.

3.1.1 Residential buildings

Decentralization: Decentralization advocates for creating an territorial environment with life functions accessible in short distance, as in 15-min cities, a concept launched by former Paris mayor Anne Hidalgo, who propelled the creation of bicycle lanes and reduced car presence in Paris [27], [28]. It would thus have an impact on urban forms and on the residential building fleet, although this effect is uncertain and diffuse. Direct effects are more easily identified in the tertiary and the transport sector (see next sections).

Right-sizing and reduction:
Statistics show a remarkable stability of average surface per home in the last decades [29] and a long-lasting trend of decreasing household size [30]. In that case, total residential surface will mechanically increase and per capita surface as well. A first sufficiency option would be to consider **stabilization of per capita surface**, which would mean a decrease in average surface per home, that would compensate for the increase in number of households, without any loss of per capita surface. In terms

of energy use, such a measure would reduce accordingly all energy consumption depending on surface (heating, cooling, lighting). It would also reduce energy demand and material demand for construction.

Within the household, **turning down space heating by 1°C and limiting hot water use** (for instance by choosing showers rather than baths) will impact the two major residential energy use.
Setpoint temperature for heating seem to have been around 20°C and more in the past decades [31], [32], despite the public recommendation of 19°C. However, many people declare they are ready to lower their setpoint temperature [32]. Moreover, the energy crisis during winter 2022-2023 actually showed a significant reduction of electricity consumption in residential sector [33]. Although it was largely driven by high electricity prices, opinion surveys showed that part of the effort was also made as a citizen gesture, and between 2022 and 2023, average setpoint temperature decreased from 19,9 °C to 19,3 °C [32]. Behavioral norms regarding heating temperature may thus change rapidly. Whether this was short-term change or long-term adoption is still to confirm: the last annual electricity review shows that consumption is still below pre-crisis levels but is starting to increase again [34], [35]. Regarding hot water use, per capita consumption of hot water is historically stable around 35 L/capita/ day of hot water (55°C). Limiting hot water use could be done by adopting water-savings practices such as replacing baths by showers [36]; which would be approximately consistent with lowering the per capita average to the lower boundary of the observed range among the population.

Utilization, timing and longevity: In the residential sector, the main application would consist in **using appliances longer or second-hand.** Such a trend already exists as the share of French people buying second hand products increased from 25% in 2009 to 48% in 2018 [37]. This will not directly reduce energy consumption of the household. On the contrary, it will slow down the replacement of appliances by potentially more efficient appliances. However, it will reduce energy demand for the manufacturing industry [38].

Sharing economy (& multifunctionality): new concepts in building and buildings use could provide more sufficiency options. Beyond traditional forms of **shared housing** such as apartment sharing or intergenerational cohabitation, co-living or eco-districts offer compact housing with access to shared services. In such housing, although each household has their individual room or apartment, mutualized spaces or appliances such as laundry rooms allow reduced average surface per capita while providing access to a wider range of spaces or services. A 2019 French opinion survey measuring acceptance of more ecological lifestyles reports that 40% of interrogated people are in favor of 'living in a place where other families have decided to mutualize resources, build and finance a dwelling in a collectively managed space with shared equipments' [39], a trend confirmed in a more recent survey on lifestyle and sufficiency conducted by ADEME [40]. Coliving, a new type of offer the in rental sector with a focus on community and convenience seems to be growing fast in major European cities like London, Paris, Berlin, and Amsterdam, with 47 % coliving operators located in Europe [41]. On a smaller scale, initiatives such as the OASIS cooperative support the development of ecological shared housing; the OASIS database monitors existing facilities: around 1500 all over France to date [42].

In terms of energy savings, the development of such housing would reduce consumption depending on surface (heating, cooling, lighting). The shared services and facilities also mean less appliances, that would have a higher utilization rate than in a classic household. **Lower surface per capita and equipment rate** are here associated with higher access to service and spaces. Data is however still scarce on actual surface per capita and equipment rate in this kind of dwelling, making it difficult to carry out quantification.

To some extent, the development of housing with shared facilities could be **materially equivalent to slowing down the trend of decreasing household size**, in terms of per capita surface and appliance equipment rate.

3.1.2 Tertiary buildings

Decentralization: Historically, the number of retail outlets is decreasing, and their surface is increasing. Past trends from national statistics show a tendency to centralize with increasing average surface and less retail shopping points. With this centralizing trend though, total surface of retail shopping is decreasing [43]. Decentralization would mean reducing commercial space, with **smaller shops** but more accessible (such as in '15-min cities') and less high-size shopping malls. However, overall, it might not reduce total surface for retail shopping. Benefits would still be expected in the transport energy consumption (see transport sector).

Right sizing and reduction:
With the generalization of remote working after the Covid crisis, part of the workforce does not need to be at the office every day. According to a report published by the Ministry of Economy, 34% of jobs in France are considered as 'teleworkable' [44], while an American paper assesses a proportion of 38% in France [45]. Concretely, **remote working** on the long term could reduce office space significantly, although net benefits are still unclear, since it can create a rebound effect in residential if people move to live in larger homes in remote areas [46], [47].

As in the residential sector, **turning down space heating by 1°C and limiting hot water use** by eco-gestures and intelligent home management systems can offer savings potential. This can also be applied to **space cooling**, which is way more common in the tertiary sector than in the residential sector in France.

With the energy crisis in 2022-2023 in France, one measure was to turn down **advertising screens** as an energy savings measure during some periods of the day; environmental NGOs called for a more massive measure at that time [48]. Beyond direct energy savings from the screens' consumption, it has a clear symbolic impact in terms of coherence with the government's encouragement to practice sufficiency in individual consumption during that crisis.

Utilization, timing and longevity: In the tertiary sector, like in the residential sector, the main application would consist in using appliances longer or second-hand. As in the residential sector, the energy savings would appear in the industry sector.

Multifunctionality, Substitution and Sharing: working from home, and more flexible working norms in general, also address these three pillars. Multifunctionality applies to the home that can be used as an office space, there is partial substitution between residential space and office space, and more sharing of the office space, appliances and furniture in the tertiary sector.

3.1.3 Transport

Decentralization:
As introduced in the tertiary sector analysis, **remote working** addresses the decentralization pillar in the transport sector. Considering that an office worker can telework half a week, it would cut half of commuting trips for them. As mentioned previously, this measure could have potential rebound effects if people move to live further away from jobs.

As introduced in the building sector (residential and tertiary), decentralization advocates for **15-min cities.** The underlying idea is to provide urban form which would allow access to essential services

within reach via a 15-minute walk for all residents. This would reduce the transport demand for trips such as shopping, leisure, accessing healthcare services or commuting to school, replacing those km made by car, by walking.

Last, the decentralization pillar advocates for more local consumption, a topic that attracts more and more attention after the recent upheavals of supply chains due to COVID [49] and then war in Ukraine and in Iran. Concretely, consuming more locally made products would mean shorter freight distances.

Right-sizing and reduction: while car size and weight tend to increase continuously these past decades, there is also an increasing consciousness of the benefits of **privileging lighter vehicles**. The French administration thus introduced a tax on passenger vehicle weight from 2022, that has been updated ever since to incentivize smaller cars [50]. The direct effect in terms of energy savings and demand will be on the manufacturing side, for the industry sector (see next section). In the transport sector, it will also reduce average consumption per car.

Multifunctionality and Substitution: substitution in the transport sector will include all possibilities of **modal shift** to a less energy-consuming or emitting mode: walking, cycling (or switching to a two-wheeler) and using public transportation. It is closely linked with the multifunctionality pillar, that would advocate for a territory allowing multi-modal transportation. For short distances, modal shift to walking has been partially treated with the decentralization pillar and the development of 15-min cities, and the associated reduction of car use for some trips. For long distances, one already applicable measure is the shift from car and plane to train for national trips where the train option exists, as was adopted by decree in 2023 [51].

Sharing economy: **shared mobility** has been increasing continuously since the 2000 decade, whether for active mobility (bikes and scooters) or vehicles (car sharing, car renting between individuals) [52]. It can reduce direct energy demand for instance when two people share a ride to work, but also, in the long term, the demand for vehicles in the manufacturing sector (see industry section). While modal shift towards environmentally friendly modes of transportation would seem easier in urban areas (or areas with a certain level of density), car sharing could be a sufficiency option in lower density areas such as peri urban areas.

3.1.4 Industry

For the industry sector, we mainly identify energy and materials savings deriving from sufficiency actions in the buildings and transport sectors.

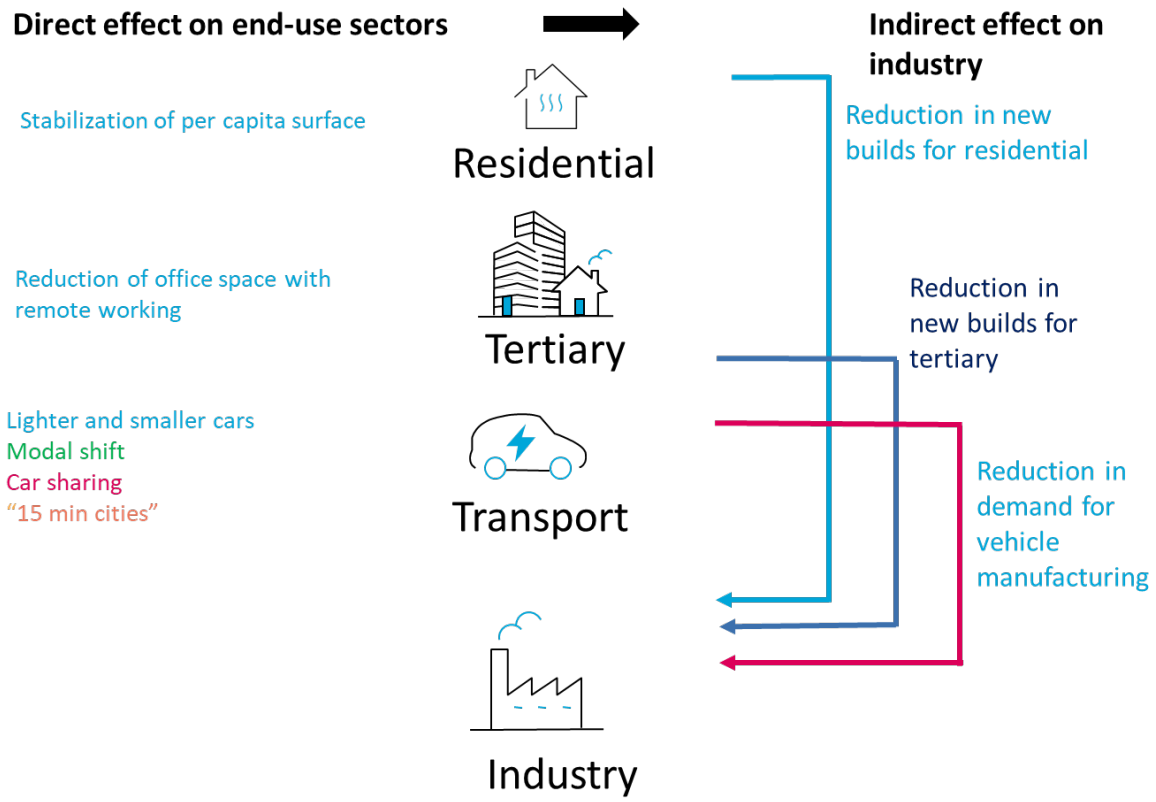


Figure 5: effects from en-use sector sufficiency measures on industry sector

Decentralization: the main identified effect is the reduction in demand for cars linked with 15-min cities. 15-min cities reduce both total modal share of cars and distance per vehicle.

Right-sizing and reduction:

Reduction in surface demand in the residential sector and the tertiary sector will be translated into proportional **reduction in energy and materials demand for construction**. Reduction in vehicle size means less energy and material demand for car manufacturing.

A measure not deriving from other sectors, the reduction of paper and plastic for wrapping as encouraged by the 2020 law on waste reduction [53] would directly reduce the demand for the paper and plastic sectors in industry.

Utilization, timing and longevity: longer appliance lifetime, whether longer utilization or second-hand products, will directly impact the associated energy demand in the manufacturing industry.

Multifunctionality: A measure not deriving from other sectors, the industry itself could conceive more multifunctional products.

Substitution:
As in the Decentralization pillar, modal shift from vehicles towards more environment-friendly transportation modes would **reduce demand for cars**. However, if public transportation is to be reinforced to allow this modal shift, such an investment would create an increase in demand for industry in public transportation material (trains or buses, etc.) and associated materials for associated civil engineering.

Beyond effects deriving from end-use sectors, the substitution pillar includes the appetence for more closeness to nature, more natural materials or organic food. In the industry sector, such a trend can be declined in several measures:

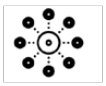
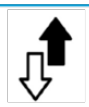
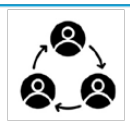
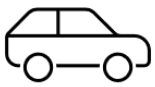
- a sufficiency measure for construction would be increasing the use of **biosourced material construction** instead of high-energy materials such as concrete, as encouraged by the 'biosourced building' label created by the government [54].
- In the agricultural sector, recent trends in France show a strong concern for high quality agricultural products, as the upheaval around the Duplomb law[6] showed [55]. In a sufficiency scenario, this could translate into the development of more organic agriculture, resulting in **less demand for nitrogen fertilizers, chemical intrants, and pesticides for the chemical industry**.
- Similarly, sufficiency advocates for **less processed food**, more home cooked meals, which would reduce the demand for the agri-food sector.

Sharing economy: like 15-min cities and modal shift, car sharing in the transport sector influences demand for cars.

All identified sufficiency measures are presented in Table 1.

[6] Duplomb law on agriculture regulation planning planned to re-authorize some previously banned pesticides in its first version.

Table 1 : Sufficiency measures identified by applying the sufficiency modelling framework to energy consumption and material consumption trends by sector

	 Decentralization (where)	 Right-sizing and reduction (How much)	 Utilization, Timing and Longevity (When and how long)	 Multi-functionality (Combined services)	 Substitution (How)	 Sharing (Owning or Using)
 Residential	'15 min cities': change in urban form	Stabilization of per capita surface Turning down space heating by 1°C Limiting hot water use	Longer equipment lifetime	Remote working		Shared facilities and equipments in housing, co-living
 Tertiary	'15 min cities': smaller shops	Reduction of office space with remote working Turning down space heating by 1°C Limiting hot water use Turning down advertising screens	Longer equipment lifetime	Remote working		
 Transport	Remote working: less daily commute '15 min cities': less trips for shopping, daily life Local consumption: shorter freight distances	Lighter and smaller cars (see industry)	Longer vehicle lifetime	Allowing multi-modal transportation on the territory	Modal shift	Car sharing
 Industry	'15 min cities': less demand for cars	Less demand for construction sector Lighter and smaller cars: less demand for vehicle manufacturing	Longer lifetime: less demand for appliances, vehicles	Conceiving mutli-functional products	Modal shift : less demand for cars but maybe more for public transport Less processed food, less nitrogen fertilizers and chemical intrants Reduction of one-use plastics Biosourced materials for construction	Car sharing: less demand for car manufacturing

3.2 Quantified energy and material savings per sector

This section presents the results of the quantification of sufficiency measures from the previous section.

Sufficiency measures that carry out direct energy consumption reduction by themselves were quantified. For measures that a likely to develop over a long period of time, we assessed the potential of deploying it by 2050. The energy or material reduction potential is expressed in percentage compared to a counterfactual business-as-usual situation. To illustrate quantitatively, these reduction potentials are confronted with the latest energy consumption data per sector in the results section. Detailed calculation can be found in the Supplementary material.

Results are presented per sector and energy and material savings per sufficiency measure are summarized in the tables below. Since these measures are embedded in lifestyle, two distinct measures may have overlapping effects or on the contrary, be multiplied by one another, which is why they cannot be summed as is.

3.2.1 Residential buildings

In the residential sector, quantified measures were identified for the right-sizing and reduction pillar. Stabilizing per capita surface and savings practices regarding heating and hot water directly induce energy savings. Savings from 15-min cities or the development of shared housing in innovative forms would require modelling on a larger scale than the household scale.

Table 2: Results for the residential sector

Energy use (2021)	kWh per household	national consumption in TWh	Sufficiency measure	Energy consumption reduction potential
Heating	8345	337	Stabilizing per capita surface to 41 m2/capita (current level)	-8% for surface-dependant consumption
			Turning down space heating by 1°C	-7% for heating
Hot water	1310	49,1	Saving practices for hot water	-33% for hot water
Specific	765	74,8	Stabilizing per capita surface	-8% for lighting

3.2.2 Tertiary buildings

In the tertiary sector, direct savings were quantified from stabilizing shop surface and remote working, measures that would both limit tertiary surfaces a priori. Rebound effects on the multiplication of smaller shops or having larger homes for people who telework were not assessed.

Table 3: Results for the tertiary sector

Energy use (2019)	kWh per m^2	national consumption in TWh	Sufficiency measure	Energy consumption reduction potential
Heating	103	101,4	Stabilizing shop surface in retail branch	for retail surfaces: -11% per shop
			Remote working	for office surfaces: - 24%

			Turning down space heating by 1°C	on all surfaces : -7%
Hot water	23	22,6	Saving practices for hot water	-33% for hot water
Specific	11	70,3	Stabilizing shop surface & remote working	for lighting: similar energy reduction as in heating (proportional to surface)
Cooling	70	21,5	Stabilizing shop surface & remote working	for cooling: similar energy reduction as in heating (proportional to surface)

3.2.3 Transport sector

In the transport sector, directly quantifiable measures were identified for the decentralization pillar, with remote working cutting part of the daily commuting trips, while 15-min cities can be assessed to suppress some car trips for shopping and errands around services ('shopping, leisure, administrative' in the consumption data); simplified quantification examples are given for the substitution and sharing pillars in the industry sector.

To be properly considered, 15-min cities and modal shift (either for passenger transport or freight) would require extensive cross-sectoral modelling between the transport sector and the building sector to assess comprehensively the change in modal shares and total distances. Cross-sectoral modelling with the industry sector would also be needed to assess the total trade-off in energy and material demand (for public transportation vs individual transportation).

Table 4: Results for the transport sector

Individual transport (2022)	Annual distance decomposition (km)	Sufficiency measure	Energy consumption reduction potential
Long distance	3000	modal shift to train	Depends on the availability of alternative train routes.
Daily commute to work	3000	remote working: cutting half trips for a remote worker	-4% on average annual distance
Shopping, leisure, administrative…	3240	15-min cities: modal shift for urban areas	-8% on average annual distance

3.2.4 Industry sector

The savings in the end uses sectors are directly reflected in some of the energy and material consumption in the industry sector, as shown in Table 10.

Regarding the effects from the transport sector, for vehicle size, average weight reduction is assumed considering that the lightest category of cars is adopted by most households, except for households with large families and households living in low density areas. The effects of modal shift and car sharing on the French fleet were illustrated examples. Modal shift was illustrated considering developed countries with the lowest modal shares for passenger vehicle: Austria, Switzerland and Japan, and

assessing the reduction in vehicle fleet associated with these modal shares. The effect of more car sharing was illustrated considering occupancy rate of vehicles going back to the level of the nineties.

For appliances, the effect of 50% extension of lifetime was assessed on demand.

In the construction sector, floor space reduction compared to the baseline was assessed for residential dwellings, offices and shops.

However, this is only a partial view, as associated effects could go either way on the total demand for industry. On the one hand, reduced consumption (such as smaller cars or appliances with longer lifetime) could have a myriad of effects in the industry, beyond the proportional reduction linked with product size or volume of sales. On the other hand, several measures such as 15-min cities and massive modal shift would require infrastructure change, which would mobilize the industry sector as well: less demand for cars, but more for public transportation.

Table 5: Results for the industry sector

Industry	Energy consumption by subsector (2023, TWh)	Sufficiency measure	Energy consumption reduction potential
Transport material	12	Reduction in vehicle size Reduction in vehicle demand due to modal shift Reduction in vehicle demand due to car sharing	-11% on energy and materials for one vehicle -12% to -25% when taking lowest modal share in developed countries -10% when going back to 90's occupancy rates
Machines	17	longer lifespan (x1,5)	-33% for equipment demand
Construction	18	Stabilizing per capita surface in residential Remote working in tertiary Smaller shop size	-8% reduction for one average dwelling in residential building, on energy and materials -24% for office branch construction, on energy and materials -11% per shop but uncertainty on total shop surface

4 Discussion and conclusions

This paper offers a quantified view of energy and materials savings that could be derived from a sufficient lifestyle with collective organization.

4.1.1 Summary of identified energy and material savings

For households, direct effects that were quantified in residential energy consumption and individual transport distances mainly show savings around a few %, **between 5 to 10% as an order of magnitude** for most measures. While such an order of magnitude may seem low, cumulated effect can be non-negligible on household energy bills. Beyond energy savings on the bill, systemic measures such as

sharing practices in housing, extending lifetime of appliances, modal shift and 15-min cities reduce the need for buying or replacing equipment such as a washing machine or a car, which represents significant savings for households.

In the tertiary sector, systemic effects of remote working or 15-min cities are likely to be significant, but potential offset by rebound effect can also be huge, which may limit savings of these measures.

In the industry sector, we observe significant effects deriving from measures in end-use sectors. Reduction in demand for construction, for cars and for appliances can have cumulated effects that will significantly reduce both energy demand and material demand. Orders of magnitude are **savings above 10%** for both construction materials (cement, sand, aggregate), and materials for cars (steel, aluminum, copper, lithium, cobalt, nickel). While such demand reduction is positive for trade balance and sovereignty, it also means a reduction in economic activity. Comprehensive modelling would allow us to assess how much of these effects are offset by other systemic sufficiency measures that could not be quantified here, such as deployment of public transportation infrastructure. **However, this study allows us to put light on the underlying energy and resource savings embedded in households' lifestyle change in addition to the direct savings at household level.**

4.1.2 Limits on sufficiency trends adoption

Although the paper relies on existing trends towards sufficiency, one major caveat is that they are generally not representative of the majority, rather a disruption compared to current trend in most households, which questions the scalability of such a lifestyle. Demand-side reduction measures may be contrary to consumers' aspirations in large shares of the population. Besides, most of measures cannot happen without strong public policies and public investment. Below is a summary of these main limits.

4.1.2.1 In the residential sector

French people have been expressing their preference for single family dwelling for more than half a century [56]. Household size has been decreasing since the 1970s (3,1 people in 1968, 2,3 in 2008, 2,2 in 2016). Less cross-generation living, later couple forming or separations, smaller families and increasing life expectancy contribute to this decrease [30]. A survey conducted in 31 countries found that only 5% of respondents would adopt a smaller living space or switch to co-housing within the next year [57]. In sufficiency modelling, the assumptions about adoption rates should be carefully examined.

Setpoint temperature has been around 21°C rather than 19°C [31] although opinion survey show that French people are in favor of saving heating [32].

Consumption of appliances has been increasing for years and their lifetime is stable for the past decade – thus has not started to increase [58].

4.1.2.2 In the tertiary sector

There is an uncertainty about the long-lasting existence of teleworking. Most opinion surveys [59], [60] show that employees are in favor of telework; however opinions differ between employees and manager. Some companies have notably stopped or reduced teleworking [61].

Also, telework itself may not be in favor of sufficiency as there is a known rebound effect in longer commuting distance (still compatible with sufficiency if in train though) and larger housing surface [46], [47].

4.1.2.3 In the transport sector

The long-lasting aspiration of French people for living in a house also often implies living in an area where a car is needed.

Some emerging trends in freight are not in favor of reducing freight distances: online shopping makes freight increase, and it has been steadily increasing over the past decade - between 2020 and 2026, sales revenue of online shopping increased by 10% per year on average [62].

4.1.2.4 In the industry sector

Notably, the recent failure of international negotiations on plastics [63] and promulgation of Duplomb law in France [55] despite strongly opposed opinion show the difficulty in reforming deeply and quickly industrial ways of producing. Concerns for national competitivity on the international market usually come first.

4.1.3 Limits and gaps for quantification

This paper offers quantification of sufficiency measures for direct effects and identifies the modelling needs to assess the potential savings from sufficiency on a more systemic level. Direct effects linked with changes in daily practices for households are observed to be around 5-10% roughly (savings on heating or effects of cutting car trips with remote working), except for savings for hot water that are larger. More systemic effects, when quantified, could potentially reach much higher consumption reduction, like the examples of massive modal shift on car manufacturing may suggest. They reflect a different organization of daily practices, with no less access to services or even improved access to services (for instance, less transport demand because services are closer in 15-min cities). Such quantification requires systemic cross sectoral modelling.

The present analysis was conducted on average household. On a broader scale, there is a need for analysis beyond average per capita or per household analysis, considering economic heterogeneity among households, geographical heterogeneity (urban, rural, peri-urban). Moreover, to be relevant, such modelling must be grounded in local analysis, region per region or country per country. Assessment of global potential of sufficiency cannot simply be derived from upscaling what has been identified or modelled in one city, region or country. Since energy consumption practices are deeply rooted in each country's lifestyles, the methodology should be applied by confronting sufficiency pillars to daily practices in relevant geographical areas (national or sub-national), and built-up in a bottom-up fashion to pursue the quantification effort on a larger geographical scale.

One major insight from this research work is that sufficiency maybe often appear as individual efforts because these are the most directly quantifiable effects. Changes in urban form through 15-min cities, development of innovative forms of shared housing, development of public transportation for modal shift cannot be deployed through individual effort but through policy choices and infrastructure work. They may have massive effect on savings for households while providing access to services and thus increase well-being. Overall, a discussion on public investments for sufficiency, an even rough first idea of amounts and savings (e.g. savings in households' day-to-day expenses, savings in imports) is essential to assess real value of such a sufficiency set of policies. Quantification of such measures on energy and material demand, as well as benefits for households' expenses, should be carried out as future research work.

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6 Supplementary Information

6.1 Data on energy and material consumption

Collected data for energy consumption per sector is presented in this section, as evoked in 2.1.1.

6.1.1 Data for main energy uses

In the residential sector, data on energy consumption per household is made available by the Statistical Data and Studies Department (SDES) of the Ministry of Ecological Transition. Main energy uses are heating, hot water, cooking, specific (lighting, appliances for cooling, washing, digital: TV, computers, smartphones and tablets) [12]. Although well present in the tertiary sector and bound to increase in years to come, cooling does not represent a significant energy use in the residential sector yet.

Table 6: Energy consumption per household (kWh)

Energy use (2021)	kWh per household	national consumption in TWh
Heating	8345	337
Hot water	1310	49,1
Specific	765	74,8
Cooking	2402	23,6

In the tertiary sector as well, data is made available by SDES. However, since the latest dataset refers to year 2020 which is a highly atypical year with the Covid crisis, we chose to use 2019 data [64].

Table 7: Energy consumption per m2 in tertiary sector

Energy use (2019)	kWh per m^2	National consumption in TWh
Heating	103	101,4
Hot water	23	22,6
Specific	11	70,3
Cooking	72	10,8
Cooling	70	21,5
Other	11	10,4

Regarding the transport sector, every decade, a large mobility survey is conducted by the SDES, which gives detailed information of motorization rate, modal share, trips and distances per household, per purpose…[13]. Here we focus on car ownership and activity levels per vehicle.

Table 8: Motorization rate per household according to areas (2019)

Type of household	Number of vehicles per household
Average household	1,2
Low density areas	1,6
Intermediate density areas	1,3

Dense areas	0,9

Bigo [14] produced a decomposition of vehicle mobility and associated distances on the previous survey: within the annual distance travelled by an average vehicle, 25% is for long distance, 25% is for daily commute to work, 4% for commuting to school, 27% for shopping, leisure, administrative; 19% for secondary trips that do not originate from the residence or return to residence.

Table 9: Decomposition of annual distance for an average car

Individual transport (2022)	Annual distance decomposition (%)
Long distance	25%
Daily commute to work	25%
Commuting to school	4%
Shopping, leisure, administrative…	27%
Secondary trips	10%
Other	11%

Industry	Energy consumption by subsector (2023, TWh)
Steel	19
Chemistry	61
Non-ferrous metals	10
Non-metallic mineral product	38
Transport material	12
Machines	17
Extractive industries (without fuels)	5
Food products, beverages, tobacco	53
Paper pulp	26
Wood	7
Construction	18
Textiles and leather	3
Unspecified	10

6.1.2 Data for associated materials demand

The French Agency for Ecological Transition (ADEME) assessed the material demand for new builds [15]. As a result, an average dwelling (average between houses and appartements) consumes 1,3 ton materials/m2 of which 84% for cement, sand and aggregate. They also provide data on vehicle weight and embedded materials. They project that between 2020 and 2050, an average thermal vehicle will weight 1 209 kg, of which 600 kg steel, 100 kg aluminum, 35 kg copper, while and average electric vehicle will weight 1 284 kg, of which 500 kg steel, 150 kg aluminum, 50 kg copper, 2-3 kg lithium, 1 kg cobalt, 6 kg nickel [16].

6.2 Results per sector – detailed calculation

This section presents the detailed calculation supporting the results in 3.2.

6.2.1 Residential buildings

In the residential sector, quantified measures were identified for right-sizing and reduction, sharing economy.

Right-sizing and reduction:

- **stabilization of per capita surface:** according the latest data available from national statistics, in 2021, there were 67,4 million people in France, 30,4 million households with 2,2 people per household [65] . INSEE's central projection to 2050 accounts for 69,2 million people, 2,0 people per household, and thus 34,0 million households [66]. Average dwelling surface is 90 m^2 and has been stable for the past decades. From 2021 to 2050, keeping the same average surface per home would mean that per capita surface would increase from 41 m^2/capita to 44 m^2/per capita. Stabilizing per capita surface at 41 m^2/capita would mean that average surface per dwelling would reduce from 90 m^2 to 82,5 m^2, a size that would reflect the new structure of the population without any loss of per capita surface. Compared to the continuation of current trends, such a measure could reduce all energy uses linked with surface: heating, cooling, lighting. Compared to the continuation of current trends, such a measure could reduce all energy uses linked with surface: heating, cooling, lighting by equivalent i.e. -8 %.
- **turning down space heating by 1°C and limiting hot water use.** Reducing setpoint temperature by 1°C means a 7% saving on energy consumption according to the National Environment Agency [67] although this is an average estimation and the result will vary according to thermal characteristics of buildings and also behavior of occupants (whether the -1°C degree reduction occurs only during the day for households who already had a lower setpoint temperature, or also at night, etc.). Regarding hot water use, per capita consumption of hot water is historically stable around 35 L/capita/ day of hot water (55°C) with two thirds of the population in the 25 L – 80 L range. Limiting hot water use could be done by adopting water-savings practices such as replacing baths by showers [36]; which would be approximately consistent with lowering the per capita average to the lower boundary of the observed range. An quantification of voluntary savings could be taking the ratio of replacing baths by showers, as ADEME assesses a bath to consume 120 L of water and a shower 40 L[7] [36], which means a 33% (one third) reduction in hot water consumption. This order of

[7] 5 min for a 9L/min debit.

magnitude is consistent with lowering the per capita average from 37 L to 25L/capita/ day of hot water (55°C) that it is the one lower third of the consumption distribution.

6.2.2 Tertiary buildings

In the tertiary sector, the pillars with quantified measure are decentralization, right-sizing and reduction, and sharing economy.

Decentralization: shop surface has been increasing from 232 m^2 in 2009 to 2050 m^2 in 2014 [68]. Stabilization at 263 m^2/shop rather than growing up to 293 m^2/shop (pursuing the trend for a decade) would mean a -11% surface reduction per shop.

Right sizing and reduction:

- **remote working**: in office jobs, remote working is already triggering reduction of office space. Today's average surface per employee is 27 m^2 in the office branch, as there are 8,6 million office employee in 2023 according to national statistics [69], and 229 million m^2 of offices in 2023 [70]. While assuming that office job could telework half a week could bring to downsize office space by half, so 13,5 m^2/employee, historically, minimum per employee space recommendation from the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases is 15 m^2/employee [71], which we take as a floor value. We also consider a medium assumption 21 m^2/employee, which may be less drastic than taking the minimum. As a result, floor space per employee is reduced by -20 % with medium assumption, up to -44% with minimum recommendation. At national level, with a trend of 0,3% growth in employment as projected by the ministry of labour [72], medium assumption would represent a -24 % reduction on necessary surfaces in 2050 (200 million m^2 instead of 248 million m^2). Sufficiency on office surface risks being offset by the rebound effect on both housing surface and commuting distance if people move further away for a larger dwelling (see discussion section).
- **turning down space heating by 1°C**, limiting hot water use (ratio between shower and bath): as in the residential sector, we assess a 1/3 reduction.

6.2.3 Transport sector

In the transport sector, directly quantifiable measures were identified for the decentralization pillar; simplified quantification examples are given for the substitution and sharing pillars.

Decentralization

- **remote working**: the activity savings were assessed for an average car whose owner teleworks half a week, and then reaggregated into an average car. An average car runs 12 000 km a year on average in 2022 [73]. According to Bigo's analysis of past INSEE's survey on transport [14], among these 12 000 km a year, 25% is dedicated to daily commute to work, 25% to long distance that is mainly for vacation, 50% for other trips that include shopping, transporting children to and from school and other activities, leisures. Counting that remote working will cut half of commuting trips for office jobs, remote working represents a -13% km per year activity decrease for a teleworker. Given that active population is 30,6 million people among 67,0 million in the latest national data [74], [75], which means that in 1 in 2,2 people are active per household on average, and that 34% of jobs are teleworkable [44], it represents an average

activity decrease of -4% per year for an average car. As mentioned above, such a reduction can be offset by rebound effect if people move further away from their offices.

- **15 min cities:** among the 12 000 km a year run by a car, 50% of distances are dedicated to other trips than daily commute and long distance. These distances are composed mainly by 4% for commuting to school, 27% for shopping, leisure, administrative, and 10% for secondary trips that do not originate or end at home [14], see **Error! Reference source not found.**. We consider that daily commute to work and to school are incompressible, while long distance and secondary trips are out of scope; 15-min cities would thus reorganize the trips for 'shopping, leisure, administrative', for households in dense urban areas, which represent 40% of the population; their motorization rate is 0,9 car per household [13]. 15 min cities would reorganize 27% of the distances for these households. The distance per car would fall to around 8800 km per year for urban household, with would lower the national average by around 8% (from 12 000 km to around 11 000 km).

Substitution:

- **modal shift** to walking, cycling and public transportation in urban areas, as well as modal shift for long distance, require extensive modelling and is out of scope.
- substitution in the transport sector will include all possibilities of **modal shift** to a less energy-consuming or emitting mode: walking, cycling (or switching to a two-wheeler) and using public transportation. Such substitution can occur for any kind of trip. For daily life, the development of 15-min cities has already been partially treated with the decentralization pillar, and the reduction of car use for some trips. For long distances, one already applicable measure is the shift from car and plane to train for national trips where the train option exists. Quantifying the potential of modal shift linked with a change in urban form and significant investments in the public transportation system, however, would require systemic modelling of the transportation sector and its cross-sectoral interactions with the buildings sector. Identifying how much modal shift could reduce the share of vehicle in total demand transport, and the implied savings both in terms of direct energy consumption from car use and indirect savings (energy and materials) from a lower demand for cars should be completed with the corresponding assessment of energy and materials for investment in public infrastructure; a reflection on which level of density justifies investment in public transportation systems is also needed. Such modelling exceeds the scope of this paper but should be investigated. However, for sensitivity analysis, the link between the total national car fleet and modal shares can be explored through the modelling used in prospective studies by French TSO [76], [77], [78]:

National fleet for passenger vehicles
= total traffic x modal share of passenger vehicles / (occupancy rate x distance per vehicle)

Equation 1: total fleet of vehicles expressed as a function of total pkm traffic, modal share of passenger vehicles, occupancy rate, and distance per vehicle

Very simple quantification examples can be derived from the comparison with the countries with the lowest modal shares for cars and highest for public transportation among European or developed countries, e.g. Austria, Switzerland or Japan.
Today in France, the modal share for passenger vehicles is 86% (629,8 bn pkm) and 13,1 % of public transport (railway, bus and coaches, urban rail) in 2020 [79]. Total passenger car fleet in

France is around 40 million vehicles the Statistical Data and Studies Department (SDES) of the Ministry of Ecological Transition [73], which is consistent with the latest data on traffic, modal share, occupancy rate and average distance per vehicle per year[8]. The country with the lowest modal share for passenger vehicle within the European Union is Austria with 74%, and 21% for public transport (railway, bus and coaches, urban rail) in 2020 [79]. Still in Europe, Switzerland has an even lower modal share with 67% modal share for cars, 22,5% for public transport [83]. Among developed countries outside Europe, Japan has a particularly low modal share for cars of 63% and high share for railway with 30% [84]. Considering a modal shift towards public transportation with these orders of magnitude could lower the total French fleet between 5 million cars with a modal share as in Austria, to about 10 million less cars for a modal share as in Japan, so a reduction of the fleet between 12% and 25%. These are orders of magnitude and cannot replace a systemic modelling of each region or country's transportation infrastructure and daily practices in terms of transport. Existing modal shares are deeply rooted in each country's geography, past demographic and economic development, and culture. Such a massive shift in France would need infrastructure and investments on the public transportation side and would take years to occur. Such quantification examples, however, roughly show the extent of systemic sufficiency measures.

Sharing economy:

- As for the modal shift in the 'Substitution' pillar, **car sharing** would need to be modelled in a systemic way. Here we propose a simple example based on historical data for occupancy rate. Occupancy rate has been calculated based on surveys and monitored by the Statistical Data and Studies Department (SDES) since the nineties. It decreased from 1,76 in the nineties and has stayed stable around 1,6 people per car since the 2010 decade. Going back to occupancy rate of the nineties would reduce car fleet around 4 million, so about 10% of the fleet.

Again, these are orders of magnitude and cannot replace a systemic modelling of each region or country's daily practices in terms of transport, but they give an order of magnitude of the change that would occur with structural change in the territorial and transportation organization.

6.2.4 Industry sector

Right-sizing and reduction

- If we assume new builds follow the general trend of reduction in surface per capita, the buildings sector will have a proportional reduction in energy and materials demand for construction, that is to say 8%.
- Similarly, reduction in tertiary surface demand will be translated into a 24% reduction in energy and materials demand for construction in the office branch.
- Reduction in vehicle size: average car weight today is 1256 kg in a range where the lighest vehicles weight 1000 kg and the heaviest 2800 kg [85]. For the 2020-2050 period, ADEME projects vehicles' weight between 1 209 kg for thermal and 1 284 kg for electric, resulting in

[8] Total traffic in 2022 : 918 bn pkm for all modes, excluding only foreign cars [80]
Modal share : 86% (629,8 bn pkm) and 13,1 % of public transport (railway, bus and coaches, urban rail) in 2020 [79]
Occupancy rate : 1,6 passenger / vehicle [81]
Distance per vehicle : 12 000 km [82]

a 1247 kg average considering a 50-50 fleet. We thus project average car size around 1250 kg up to 2050 for this quantification, with the historical distribution. Considering that smaller cars would equip small households in dense areas, we keep average distribution of car size for households in low and very low density areas (32%) and for big households (couples with 2 children and more: 16%)[13]. Since we do not know about possible overlap between the two categories, we sum both.

- 48% of households keep today's average size of cars, 1250 kg (in which we suppose a distribution between big and small)
- The remaining 52% have the lightest category, around 1000 kg
- As a result, average car size shrinks by 11%, and so does the associated demand for steel, aluminum, copper, and materials for batteries.

Utilization, timing and longevity

Assuming a 1,5 longer lifespan for appliances, whether through repairing and keeping the equipment longer, or through second-hand market, would mean reducing demand by one third on average. We illustrate such a measure on the sales for washing machines and refrigerators, which are the most owned equipment (about 100% equipment rate for both). Each year, about 2,5 million washing machines and 2 million refrigerators are sold in France, according to the Inter-trade organization of household goods manufacturers' data [86]. Sales are driven by renewing equipment or by the appearance of new households. Lifetime has been stable over the past decades, around 10 years for washing machines and 12 years for refrigerators [58]. Reducing demand by one third, so reducing washing machine sales to 1,7 million and refrigerators to 1,3 million a year. In terms of energy consumption, the corresponding industry subsector ('machines') has been consuming around 20 TWh per year historically [87]. Generalization of repairability and longer lifespan in such orders of magnitude would thus reduce its energy demand by around 7 TWh per year.

Substitution:

As presented in the Transport sector section, **modal shift** could mean a 12% to 25% reduction in passenger car demand based on the lowest modal share in developed countries.

Sharing economy:

As presented in the Transport sector section, **car sharing** could mean around a 10% reduction when considering going back to the nineties' level.

Table 10: Results for the industry sector

Industry	Energy consumption by subsector (2023, TWh)	Sufficiency measure	Energy consumption reduction potential
Steel	19	-	-
Chemistry	61	-	-
Non-ferrous metals	10	-	-
Non-metallic mineral product	38	-	-
Transport material	12	Reduction in vehicle size	-11% on energy and materials

		Reduction in vehicle demand due to modal shift Reduction in vehicle demand due to car sharing	-12% to -25% when taking lowest modal share in developed countries -10% when going back to 90's occupancy rates
Machines	17	longer lifespan (x1,5)	-33% for equipment demand
Extractive industries (without fuels)	5	-	-
Food products, beverages, tobacco	53	-	-
Paper pulp	26	-	-
Wood	7	-	-
Construction	18	Stabilizing per capita surface in residential Remote working in tertiary Smaller shop size	-8% reduction for residential building, on energy and materials -24% for office branch construction, on energy and materials -11% per shop but uncertainty on total shop surface
Textiles and leather	3	-	-
Unspecified	10	-	-