FULFILL

Integration of findings from Social Sciences and Humanities in quantified sufficiency assumptions for decarbonisation pathways

Consolidation of quantified sufficiency hypotheses in decarbonisation strategies

Fundamental decarbonisation
through sufficiency by lifestyle changes

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Fundamental decarbonisation through sufficiency by lifestyle changes

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Project Partners

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

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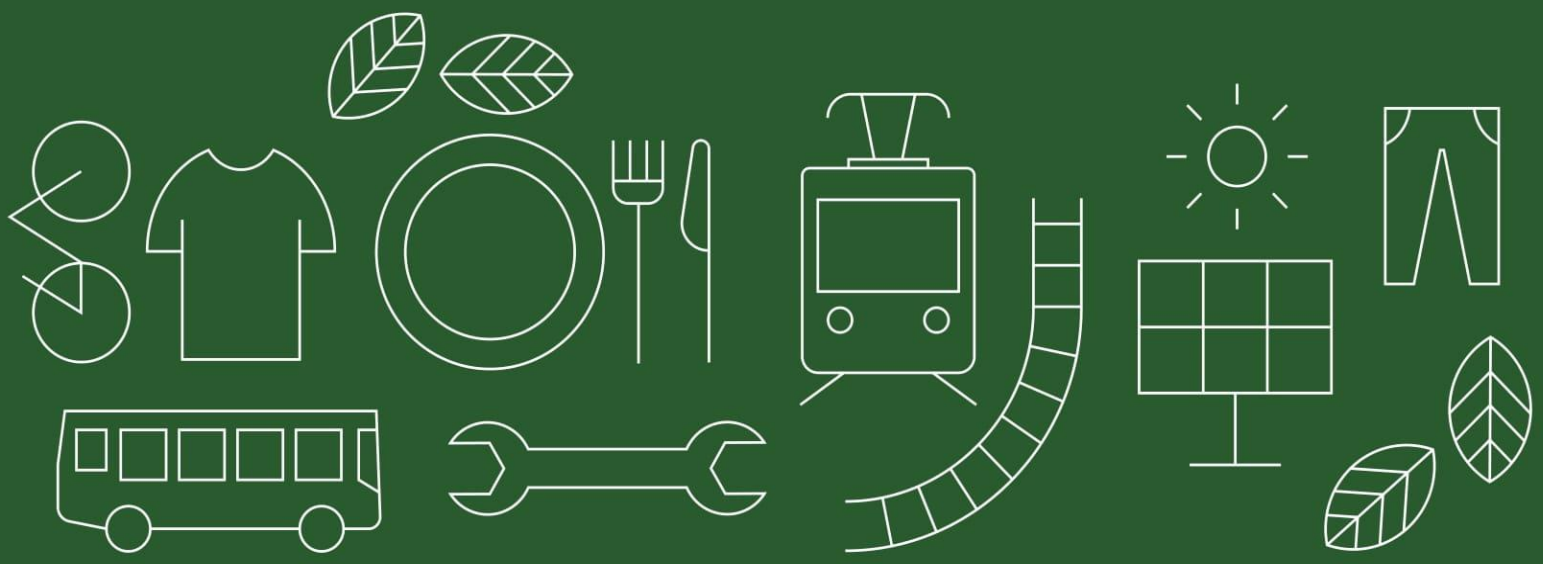

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List of Abbreviations

CO_2	Carbon dioxide
e-bikes	electric bikes
EU	European Union
EV	Electric vehicle(s)
FEC	Final energy consumption
GHG	Greenhouse gas(es)
NDC	Nationally Determined Contributions
Pkm	Passenger kilometre(s)
SSH	Social Sciences and Humanities
TX.Y	Task X.Y
WP	Work Package(s)
WTR	Working time reduction

List of Tables

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Abstract / Summary

This report presents the work carried out in Task 5.3 of the FULFILL project about the quantification of sufficiency levers – i.e. changes in habits, activities and services, that contribute to less energy and GHG-intensive lifestyles – in decarbonisation pathways. It explores ways to integrate Social Sciences and Humanities (SSH) findings into the construction and justification of "*sufficiency scenario assumptions*" to improve the quantification of projected changes towards more sufficient lifestyles at the national level in five European countries: Denmark, France, Germany, Italy and Latvia. By "*sufficiency scenario assumption*" we mean the projected changes for a given sufficiency lever (e.g. shared housing) on a set of sufficiency indicators (e.g. square meters per capita), from a starting point to a target year, including a characterisation of the pace of change with a defined time step, as they could result from such a construction.

This methodological exploration is carried out through the study of eight sufficiency scenario assumptions, selected according to several criteria, such as their quantifiable nature, their potential impact in terms of energy and GHG emissions reductions, their link with previous work packages or the possibility of describing them based on a distribution between different social groups. The sufficiency scenario assumptions studied in this report relate to the following levers: change towards more sustainable and healthier diets, cohousing, sharing space in housing, sharing products, moderate car sizing, increasing biking in daily trips, flying less and working less. This report presents the general methodology used to quantify these eight scenario assumptions, which is based on the following steps: choosing a precise perimeter of change related to the chosen sufficiency lever and corresponding indicators; characterising past trends and the current situation on the basis of existing macro-data; identifying enablers, barriers, and potential dynamics across different social groups; analysing how policies and measures can build on enablers and overcome barriers; finally resulting in a quantified trajectory of change related to the chosen indicators. The report then details the tailored implementation of the methodology and results for each of the scenario assumptions, along with some specific points of discussion regarding the trajectories constructed.

Research contributions and limits of the work carried out are discussed in a dedicated section. The concluding thoughts highlight the importance of considering social determinants in the transformation of lifestyles towards sufficiency to improve the design and implementation of decarbonisation pathways. This exploratory work shows that integrating SSH knowledge into sufficiency prospective studies on energy and climate makes it possible to question the balance between feasibility and ambition from a social point of view, and to build a more detailed justification of the related projections. Using insights from SSH can make scenarios more robust, consistent, fit for public discussion and useful for policymaking. This work also suggests a way of better integrating and articulating policies and measures for the short, medium and long term, and elaborating more relevant and tangible narratives. It would be interesting to take this work further through more interdisciplinary research across SSH and prospective studies, i.e. techno-economic research on energy and climate pathways. This work could serve as a basis to discuss how future sufficiency-based scenarios could be improved by using information from SSH and how qualitative or quantitative surveys could be developed for this purpose.

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Introduction and Overview

Purpose of this Document

This deliverable is produced within the framework of the FULFILL project (see description below) and is an important part of the analyses led at the **macro level** (see Figure 1) about the characterisation and quantification of sufficiency levers on a national level (i.e. Work Package (WP) 5), where we focus on the identification and analysis of structural drivers in the diffusion of lifestyle changes towards deep social transformation at the macro level.

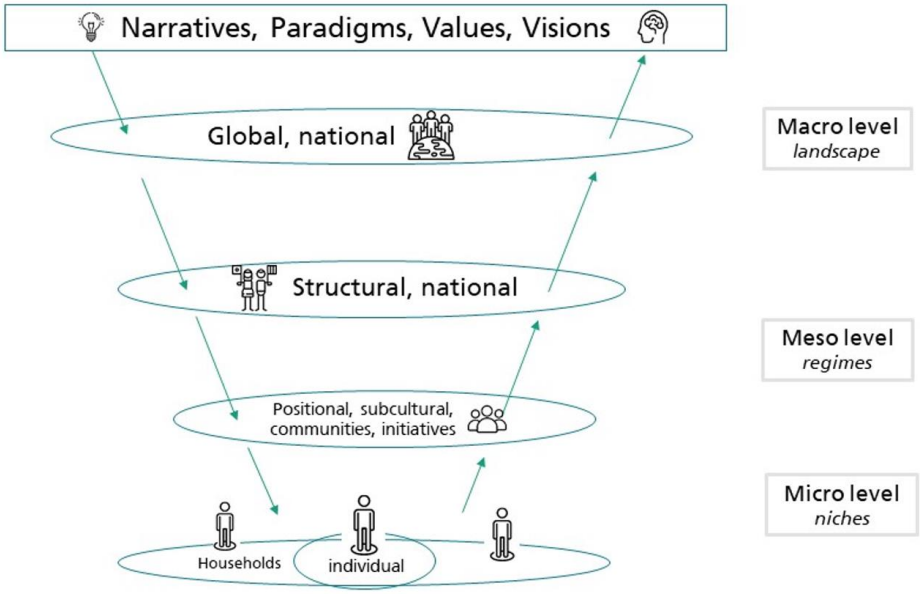

Figure 1: Overarching framework for lifestyle analyses on societal different levels (FULFILL, 2022)

We present in this report the work carried out in Task 5.3 (T5.3), which is about the quantification of the possible projection of sufficiency levers in decarbonisation pathways. The main objective of this task is to explore how to **consolidate the way key sufficiency scenario assumptions are quantified in energy and climate scenarios, by integrating SSH findings.** In other words, the aim is to experiment with ways of taking into account, in a rather detailed way, the social determinants – enablers and barriers – at play in spreading or hindering lifestyle changes towards sufficiency when building decarbonisation trajectories. This methodological exploration is led through a selection of eight scenario assumptions. By "*scenario assumption*" we mean the projected changes for a given sufficiency lever on a set of sufficiency indicators, from a starting point to a target year, including a characterisation of the pace of change with a defined time step. We refer to FULFILL (2022), where "*sufficiency levers*" are defined as "*changes in habits, activities and services, that contribute to less energy and GHG-intensive lifestyles*". They can be found in all key areas and sectors (e.g. reducing living space sizes) and are associated with "*drivers*", which are defined as "*modifications brought to infrastructures and societal frameworks, such as policy measures, that support and enable the sufficiency levers*" (e.g. development of a more compact and frugal architecture).

This report builds on upstream FULFILL activities. First, we refer to the literature review detailed in FULFILL (2023a) and the research design refined in FULFILL (2022), in which methodological recommendations were formulated "*to improve the consideration of sufficiency-related changes in energy and climate pathways*". We then use findings from WP3 (empirical analysis of lifestyle change mechanisms and sufficiency lifestyle through SSH methods on the micro level, i.e. individual and household) and WP4 (analysis of enablers and barriers for sufficiency lifestyles on the meso level, i.e. intentional communities, local initiatives and municipalities). We also build on FULFILL (2023e) for the macro-analysis of structural variables and conditions behind the

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diffusion of sufficient lifestyles. Finally, we use findings from FULFILL (2023f), which aims to analyse the role of policies and governance measures in the diffusion of sufficiency lifestyles at the macro level.

The set of sufficiency scenario assumptions quantified in T5.3 will then provide the core quantification for T6.1, which aims at passing from the detailed indicators quantified in T5.3 to proper inputs to feed the impact assessment models used in T6.2 and T6.3 (impact on GHG emissions, energy consumption, economic and social factors). Ultimately, this work will inform the role sufficiency can play in decarbonisation strategies and Nationally Determined Contributions (NDC) (T6.5) and help formulate sound policy recommendations for the development of sufficiency lifestyles (T7.2).

The methodology followed in this work is explained in the first chapter of this report. The construction of quantified trajectories is then presented for each of the sufficiency scenario assumptions studied (Chapter 2). In Chapter 3, we analyse the research contributions and limits of the work carried out and identify a number of avenues for further research. Finally, the lessons learnt from this exploratory work are presented in conclusion (Chapter 4).

Project Summary

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

Project Aim and Objectives

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

- Characterise the concept of lifestyle change based on the current literature and extend this characterisation by combining it with the sufficiency concept.
- Develop a measurable and quantifiable definition of sufficiency to make it applicable as a concept to study lifestyle changes in relation to decarbonisation strategies.
- Generate a multidisciplinary systemic research approach that integrates micro-, meso-, and macro-level perspectives on lifestyle changes building on latest achievements from research into social science and humanities (SSH), i.e. psychological, sociological, economic, and political sciences, for the empirical work as well as prospective studies, i.e. techno-economic energy and climate research.
- Study lifestyle change mechanisms empirically through SSH research methods on the micro- (individual, household) and the meso-level (community, municipal);
- achieve an in-depth analysis of existing and potential sufficiency lifestyles, their intended and unintended consequences (incl. rebound and spillover effects), enablers and barriers (incl. incentives and existing structures) as well as impacts (incl. on health and gender) on the micro level across diverse cultural, political, and economic conditions in Europe and in comparison to India as a country with a wide

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range of economic conditions and lifestyles, an history which encompasses simple-living movements, and a large potential growth of emissions.

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

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1. Methodology

1.1. What is meant by "sufficiency scenario assumption"

By studying a sufficiency scenario assumption, we mean investigating a specific sufficiency lever by projecting the lifestyle and societal changes that could occur if political institutions and policy makers were to implement sufficiency measures, invest in sufficiency infrastructure, and propose a political and cultural framework to foster said lever. Instead of trying to predict what *will* happen, the goal is rather to project what *could* happen.

In sufficiency scenarios, addressed issues are for instance reachable levels of sufficiency, benefits and co-benefits, limitations, conditions of implementation, equity concerns, etc. (FULFILL, 2022). While this task considers these issues for each sufficiency assumption, its primary goal is not result-oriented but rather method-oriented: exploring the integration of SSH findings in energy and climate prospective as mentioned above, to try to remedy to limitations induced by not considering lifestyle changes and social groups (Ibid).

1.2. Selection of the sufficiency assumptions

1.2.1. Selection process

Because of time and material limitations, this exploratory task focused on the quantification of a selection of sufficiency scenario assumptions. At first, we proposed a non-exhaustive list of 50 sufficiency levers based on our knowledge of existing sufficiency scenarios and levers identified in the research design (FULFILL, 2022).

A selection process was therefore needed. From a methodological perspective, the global objective of this selection was to reflect the different goals of the task, taking into account the nature and availability of existing material and the exploratory purpose of this work. After some exchanges with partners, further discussion was held within the négaWatt team to formulate a list of detailed objectives. It concluded in the need for the scenario assumptions to be as much as possible:

- diverse and representative of the whole range of sufficiency-related changes in lifestyles, therefore covering various sectors and situations,
- specific enough to support the kind of detailed characterisation and reasoning aimed for,
- bearing sufficient impact to be significant to work on,
- distinct in terms of related dynamics, and the nature of infrastructures or societal changes that they might require, therefore possibly diversifying the fields of policies and measures that they would call for,
- featuring levers that are never or rarely included in the scenarios reviewed in FULFILL (2022) to expand the exploration to "new" levers,
- connected to items covered or touched upon in the SSH analyses of the project, to serve the purpose of taking stock of the subsequent material,
- fit for statistical analysis in the five countries, also to allow reflection on the impact of national contexts,
- touching on changes and indicators that could be grasped by modelling tools as planned in T6.1, T6.2 and T6.3, to allow for exploring how to further assess the corresponding environmental, economic and social impacts.

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Although all of these objectives were deemed important, none of the levers identified would equally fit all of them. There may even be trade-offs in some cases, e.g. the willingness to favour levers investigated in previous tasks and the necessity to choose levers with quantifiable and significant impact. For example, cohousing is interesting as this practice was investigated in T3.2. However, it is quite niche (see section 2.2) so data availability at national level was uncertain. Moreover, the situation regarding policies or statistics would vary so much depending on countries and items that no perfect match could be found.

It was therefore proposed to develop a scoring process that should result in a selection of levers which addresses the different objectives above and ensures some balance between them.

To this end, a first series of selection criteria were chosen in relation to the objectives of the project and the task to evaluate the relevancy of suggested levers. Levers were ranked against chosen criteria on a subjective score of 0 to 5 by négaWatt team members, each focusing on criteria regarding their area of study (either SSH or prospective studies). This process narrowed down the number of levers to 17, but as scores were very close, further selection was needed. Therefore, further qualitative considerations were introduced in a second round with additional criteria to narrow further down to eight assumptions.

Assumptions were also discussed with EURAC and WI to evaluate the possibility of linkage with work package 6 (WP6). As there were no major issues, no assumptions were discarded on that basis.

2.2The selection process therefore combined a scoring approach, based on a selection of criteria that are summarised in Table 1, framed in a broader qualitative discussion within the négaWatt team. The scoring results are available in the annex of this report (see Table 28).

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Table 1: List of selection criteria

Selection Round	Criteria name	Evaluation question
1	Ability to quantify	Are the sufficiency practices leveraged by the scenario assumption translatable into quantifiable physical indicators? How certain is data availability?
1	Research design	Does the scenario assumption address key areas for sufficiency lifestyles identified in FULFILL (2022)?
1	Link with previous WPs and tasks (SSH findings)	Is the scenario assumption supported – at least qualitatively – by material from previous WPs (T3.4, T4.4, T5.1, T5.2)?
1	Socio-demographics	Is the scenario assumption likely to be described according to different relevant social groups?
1	Impact	What is the estimated impact of the scenario assumption on energy or GHG reduction per capita? Can this impact likely be estimated?
1	Diffusion	Are the practices associated with the scenario assumption likely to be largely adopted?
2	New content	Is the scenario assumption uncommon in energy and climate scenarios?
2	Diversity	Does the set of selected scenario assumptions cover a wide range of areas and various types of transformations and pose methodological challenges?
2	Advocacy	Are policy recommendations likely to be found and explored, and are they likely to foster the studied sufficiency lever?
2	Gender	Is the scenario assumption a possible opportunity to reduce gender inequalities?

Based on the results of the scoring, the objective was to find a portfolio of sufficiency-related items that were all meeting enough of the above criteria to be meaningful to process, while reflecting a variety of gaps, so as to test the approach through a broader scope of conditions.

In the process, the variety of sufficiency levers themselves was particularly taken into account, based on a distinction between usage (use equipment optimally to reduce consumption), dimensioning (adapt equipment size according to the actual need) and cooperative sufficiency (share equipment) (Marignac et al., 2021). Since the aim was to explore the potential of changes relating to sufficiency infrastructures and societal frameworks, sufficiency levers of a dimensional or organisational nature were prioritized.

Finally, the methodological objective is focused on exploring ways by which SSH information can enlighten the feasibility and potential impact of policies and measures to deliver on changes of infrastructures and social frameworks that allow for lifestyle changes towards sufficiency habits. Therefore, the general approach towards building projections is to reflect on dynamics in terms of progressive implementation of policies and changes, together with the progressive building of democratic support, rather than in terms of more radical policy changes, that might

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implicitly require more authoritative moves. Although that was not a criterion upfront, the selection was driven towards items that would be more prone to the progressive than radical approach.

It must also be noted that, since the purpose was to try the detailed methodology, the specific impact on energy consumption and greenhouse gas emissions of each of the selected sufficiency items was only secondary. In any case, the methodology implies to get into a level of disaggregation of the sufficiency potential where none of the considered levers has a significant impact on the global balance alone.

1.2.2. Presentation of the sufficiency assumptions retained

Below is the result of the selection process (Table 2). Due to time and data limitations, two assumptions were investigated but not quantified.

Table 2: List of the eight sufficiency scenario assumptions investigated

Sector	Lever	Assumption	Method of Treatment
Agriculture	**Diets**	Diets contain less and less animal products.	Quantified
Buildings	**Cohousing**	A growing part of the population lives in cohousing projects.	Investigated qualitatively
Buildings	**Sharing space in housing**	A growing part of the population lives in shared housing. Applied only to a certain category of population.	Quantified
Products	**Sharing products**	Some products are increasingly shared between households: application to washing machines.	Quantified
Products	**Moderate product sizing**	Products are more reasonably sized and better adjusted to more moderate usages. Applied to passenger cars.	Quantified
Mobility	**Biking**	Cycling is increasingly used for daily trips.	Quantified
Mobility	**Flying less**	People fly less.	Quantified
Cross-sectoral	**Working less**	Working time is reduced.	Investigated qualitatively

1.3. Quantification of the sufficiency assumptions

1.3.1. Methodological framework

The general methodological framework of this task fits in the bottom-up physical approach developed by négaWatt and partners when building scenarios such as CLEVER (négaWatt Association, 2023). It consists in looking firstly at the demand side in terms of energy services delivered, and to project their quantified evolution thanks to sufficiency indicators, such as living space, kilometres travelled, etc.; and then derive the related energy consumption by introducing

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complementary scenario assumptions on other factors in the energy system, such as the balance of energy carriers and the efficiency of equipment.

An analysis of sufficiency-oriented scenarios (FULFILL, 2022, 2023a) shows that existing modelling of the consumption of energy and resources, even though purposely developed to elaborate low-demand scenarios, tends to fall short of a detailed design and justification of sufficiency-related assumptions, for a series of previously identified reasons (Förster et al., 2019). For instance, some models tend to characterise changes in consumption patterns on a level that is too aggregated, in terms of sectors, use or population, to account for detailed changes in specific practices or differentiated dynamics among distinct categories. Moreover, they often use indicators and categories that do not reflect those found in existing statistics or that are used in existing SSH studies. Also, modellers might lack the capacity, even when data exists and categories fit, to go into the level of detailed analysis that would be needed for each item, due to the multiplying effect when covering the whole range of consumption across all sectors. Building on these observations, T5.3 explores ways to improve sufficiency assumptions by using indicators that are more disaggregated, by introducing categories to go beyond averages, and by looking at how to integrate findings from surveys or found in SSH literature as much as possible in the modelling. We use these findings taking into account their degree of certainty (see discussion section 3.3) however our review of the literature regarding each scenario assumption is partial, and we do not use SSH methods in this work.

To define and introduce these categories, we can rely on the analysis of the FULFILL survey data (collected in 2021) that was used in T3.1 to calculate the carbon footprints of respondents and that is representative of each country's population [1]. Indeed, at least for some scenario assumptions, sufficiency indicators are present in the FULFILL survey and can be disaggregated against socio-demographic variables (FULFILL, 2023c).

Also, and as shown in FULFILL (2022), when lifestyle changes are introduced exogenously into scenarios, it appears that "*the assumptions in terms of pace and level of change rely on* 'discipline-expert intuitions *and potential normative choices consistent with the scenario vision and ambition*". This risk is high when one adopts a target/vision-based approach, which consists of setting the endpoint (e.g. level in 2050) "*with a sufficiency approach in mind (convergence towards a level of 'enoughness'), and the trajectory constructed through e.g., backcasting*" (Ibid.). In this work, we intend to avoid setting the "*right*" level regardless of the possible pace of change. In other words, we aim at looking at a possible pace of lifestyle and infrastructure changes towards sufficiency, using information from SSH on existing barriers and enablers, diffusion mechanisms, and possible policies and measures, to estimate reduction potentials on a selected range of sufficiency indicators. The targets that can be introduced as a step in the construction of the sufficiency projections are therefore set in accordance with this estimate of potential; in some cases where a more normative approach is at play in setting the target (in relation to findings from existing scenarios), the method leads instead to a discussion of the conditions for tapping the potential up to the corresponding target.

Along with the objective of strengthening the building of sufficiency-related projections to be considered in scenarios, enhancing the transparency of the process is also very important. The methodology is thus designed on a step-by-step basis, so that the detail of the approach applied to each projection of a sufficiency assumption – the data used, the reasoning, the quantitative application etc., with its own level of detailed and required choices, can be shared, and therefore discussed.

[1] Respondents had to fill a questionnaire to measure their individual emissions and to evaluate their level of well-being. Further questions covered socio-economic attributes, political preferences, social deprivation and gender-related division of work.

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1.3.2. Methodological steps in the quantification

To serve the purposes of the task, the work conducted in task 5.3 consists mostly in refining the construction of projections regarding changes related to detailed sufficiency levers. Each of these is discussed separately, as if it were projected under a *ceteris paribus* principle, although some interactions with other levers and practices and the related limitations are considered on a case-by-case basis. The methodological steps were defined to ensure consistency of processing for each of the scenario assumption, although a balance had to be found to keep some flexibility as this work is exploratory and the diverse set of scenario assumptions might need different approaches. It is also meant to be abasis that could feed further interdisciplinary work.

The process to be followed for each scenario assumption is set as follows:

Perimeter of study and relevant indicators

The first necessary step is the choice of a relevant perimeter of study and indicator, or set of indicators, possibly including a primary and some complementary ones. The perimeter describes a precise set of practices to which the sufficiency lever is applied; the scope of the practices and/or groups targeted, and the available data should be clarified. The indicators should be chosen to represent at best practices and their degree of sufficiency relating to the scenario assumption. An ideal list of indicators can first be drafted and then refined according to the available data.

Macro data analysis, past and present trends

Whatever the level of inflection or even disruption in the projected quantification can be, it needs to build upon the existing situation, taking into account the characterisation of the starting point, but also the past evolution. The analysis of macro data must not only cover the chosen indicator(s), but can usefully be extended to additional, relevant factors, for instance relating to infrastructures that need to evolve as an enabling condition of change in sufficiency habits.

Insights from SSH and main socio-demographic variables retained to form population groups

In parallel, relevant findings arising from SSH research can be used to better understand contrasted social dynamics that possibly underpin the aggregated evolution on the macro-level, identify social or cultural barriers to change or point out enablers. It can be done through analysing sufficiency practices, declared willingness to change, expressed concerns with limitations or constraints, expectations regarding co-benefits, national contexts, etc.

This analysis can then serve to categorise the concerned population into groups. We do not suggest an unequivocal method for selecting groups for a given sufficiency scenario assumption, as the selection criteria may vary. However, an important criterion in our view, which we have systematically retained, is the possibility of differentiating the dynamics of change across these categories. Ideally, the indicators disaggregated by categories should match or connect with the existing aggregated data, at least for the starting point, so that the difference qualitatively introduced in the projected change between categories can turn into quantification. For example, the sum of quantities of animal products consumed by individuals disaggregated in different diet types should match the total quantity at the country level.

Analysing trends by looking at different groups may enable to characterise new sufficiency practices that are not visible in macro data, but may spread, even in a baseline scenario without sufficiency policies (e.g. if younger people adopt certain practices, they may spread with the effect on generation renewal).

To quantify the shares of each group, we used when applicable the data from the FULFILL survey that was designed to calculate carbon footprints (FULFILL, 2023b). When not applicable, quantitative data was searched in surveys available in literature, with a focus on Europe and France.

Guidance target

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Although not necessary for the quantification, a guidance target (e.g. taken from an existing sufficiency scenario) can be useful in several ways. Generally, it gives a direction in coherence with FULFILL's guiding principles. It can serve as a comparison to check if expected lifestyle changes meet the ambition necessary to reach climate targets, or at least how they contribute to reaching them compared to existing 1.5°C-compatible sufficiency scenarios. Thus, we conceptualise sufficiency scenario assumptions to be target-oriented and trajectory-based, instead of being target-based (which would bring too much normativity (FULFILL, 2022)), with a balance between the trajectory-based and target-based approaches tailored to the level of data available to refine the quantification on the one hand, and the information from drawn existing scenarios about the level of the target.

Barriers and enablers crossed with possible policies

Finally, the identification – not meant to be exhaustive – of barriers or enablers to change should be crossed with a policy analysis and narrative, i.e. existing or possible policies and measures that could tackle barriers and tap into enablers. Additionally, potential impacts and the timeline of these policies should be evaluated to feed the quantification, and particularly the differentiation of paces according to groups.

Trajectory for each group: quantification rationale and narrative

Firstly, a starting point should be quantified, ideally for each group. Then, the trajectory for chosen indicators should be built according to a sufficiency narrative and insights from the previous analyses: the extent to which policies can remove barriers and tap into enablers, and their expected timeline, all of which potentially differentiated by group. The translation of this analysis into a quantified trajectory depends on the scenario assumptions. There is no systematic method, especially because modelling the impact of policies would require a lot of empirical data which, in most cases, is not available as most of the suggested policies have not yet been implemented or even experimented with yet.

The methodology is summarised in Figure 2:

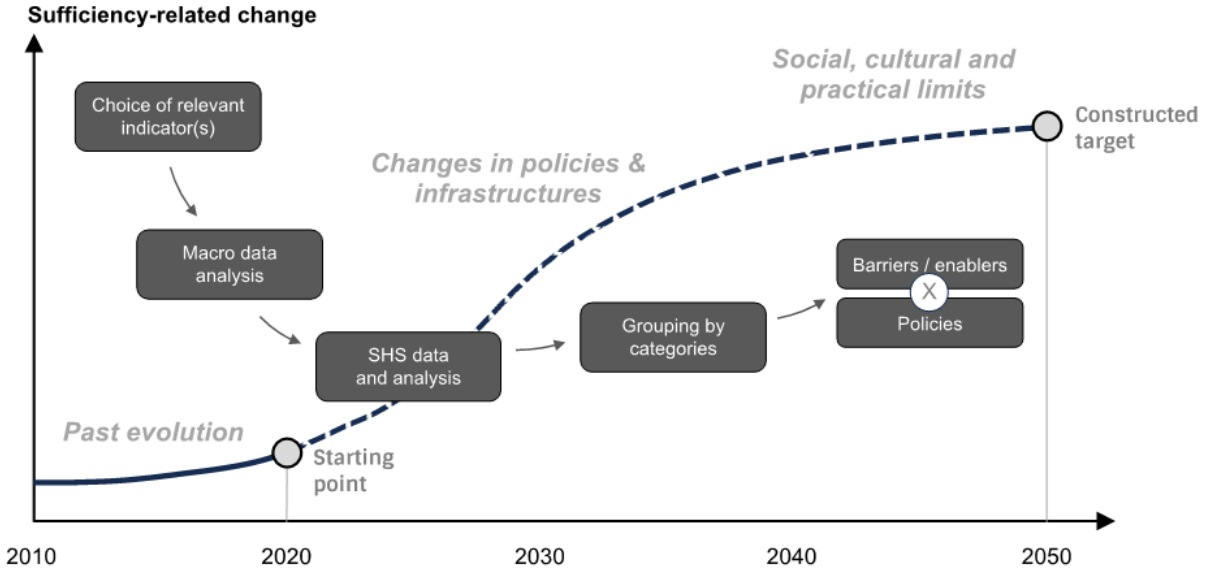

Figure 2: Proposed methodology to build detailed scenario assumptions

Compared with the current state of play of modelling capacities and existing scenarios, this proposed methodology is tailored to build more precise, justified, and robust sufficiency assumptions, particularly from the perspective of their political feasibility that is critical for decision-making. The process, however, does not appear to be straightforward. In particular, it needs to be more iterative than strictly linear, with back-and-forth moves to keep adjusting through constant questioning of the most relevant elements, continuous updating regarding

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available data, and the matching of both. This can be supported by sensitivity analyses and interdisciplinary discussion. However, we were unable to carry out such work due to lack of time.

1.3.3. Methodological limits

With regard to the selection process for sufficiency scenario assumptions, the fact of having to meet multiple criteria might constitute an important limitation. Indeed, some of the selected scenario assumptions may not perfectly fulfil all the criteria but only partially fulfil most of them; then the criterion of data availability on macro, meso and micro levels may not be fully met for several scenario assumptions.

The consistency of projecting SSH findings into a trajectory has not been evaluated. These findings may hold true in a given perimeter, and not be transposable for various reasons, e.g. they may be influenced by other changes occurring in the trajectory. Furthermore, trajectories are not intended to predict cultural changes that may happen and render certain findings obsolete. While an analysis of existing dynamics around sufficiency levers and related policies can be used to inform possible projections, it does not allow to exclude changes, that could trigger unforeseen negative reactions or backlashes following the introduction of sufficiency policies. Even assuming a society where they would be largely accepted, the way policies and measures would be introduced, and the context at the time when they are introduced could foster political opposition, or polarisation, thus creating unpredictable social dynamics. On the other hand, SSH findings may lead to make too conservative assumptions, as they reflect the current representations of possible changes. These representations might change quickly after disrupting events, and open sufficiency policy opportunities (e.g. the energy price crisis sparked a sufficiency plan in France (Euractiv, 2022)).

The willingness to adopt a non-normative approach is disputable, as FULFILL includes guiding principles which in any case define the framework for trajectories and set long-term objectives such as fostering a more sufficient society, avoiding the crossing of planetary boundaries, etc. The issue remains open, and the difficult balance between the objectives of this task is discussed hereinafter for each sufficiency scenario assumption.

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2. Quantification of eight sufficiency scenario assumptions

2.1. Diets

Table 3: Summary of the construction of the quantified trajectory for the "Diets" scenario assumption

Perimeter of study	Reducing the quantity of animal products in diets
Indicators	Quantities of foods consumed in grams per person per day and shares of diet types
Past trends	Rather stable consumption of animal protein since 2001.
Population groups	Diet type (according to observed clusters) and gender
Guidance target	Halved consumption of animal products, used as a target.
Policies	Support to alternatives, food industry regulations, availability of plant-based products, taxation, welfare policies on food, education with an attention on gendered roles, advertisement regulation. Most impactful policies are mid/long-term, less impactful are short-term.
Main elements underlying the quantified trajectory	Progressive and partial adoption of more sustainable and healthy diets based on surveys to reach the guidance target. Gendered paces: men are impacted more slowly by polices.
Main results	Shares of diet types in 2021 and 2050 by gender. E.g. in 2021, 50% of men and 36% of women are estimated to eat 2 portions of meat daily, against respectively 10% and 6% in 2050. The total animal products consumption of the 5 countries is halved.
Discussion	Issues of data limitations, uncertainties of adherence of meatless diets, lack of data to model the impact of policies, not taking into account the cultural context, equity not ensured and not visible.

Perimeter of study and relevant indicators

In this sufficiency scenario assumption, we look at the possibility of the spread of more sustainable and healthier diets in the 5 countries studied. Current diets are increasingly unhealthy, unsustainable, and inequitable for many populations (Fanzo & Davis, 2019), so looking at their possible evolutions through policy intervention is very relevant in the framework of sufficiency.

Here this is done through the angle of consumption in the framework of lifestyle changes, but it implies in parallel changes on the production side that are not dealt with in this study, given the scope of FULFILL. Nevertheless, suggested policies are not focused only on individuals, in line with the previously stated necessity of creating the infrastructural, social and regulatory conditions to change lifestyles.

The sufficiency indicators quantified in this assumption are:

- The quantity of intake foods in grams per person per day (g/p/d)
- The shares of diet types (omnivore, vegetarian, etc.)

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Macro data analysis, past and present trends

Looking at FAO data (Figure 3), we observe that the average quantity of protein of animal origin per person has been roughly stable in the last decade for the 5 countries. Quantity in Latvia has gotten closer to the other countries between 2001 in 2009, then has stabilised as well. This overall stagnation suggests that without policies to encourage a shift in consumption, a strong reduction is not foreseen.

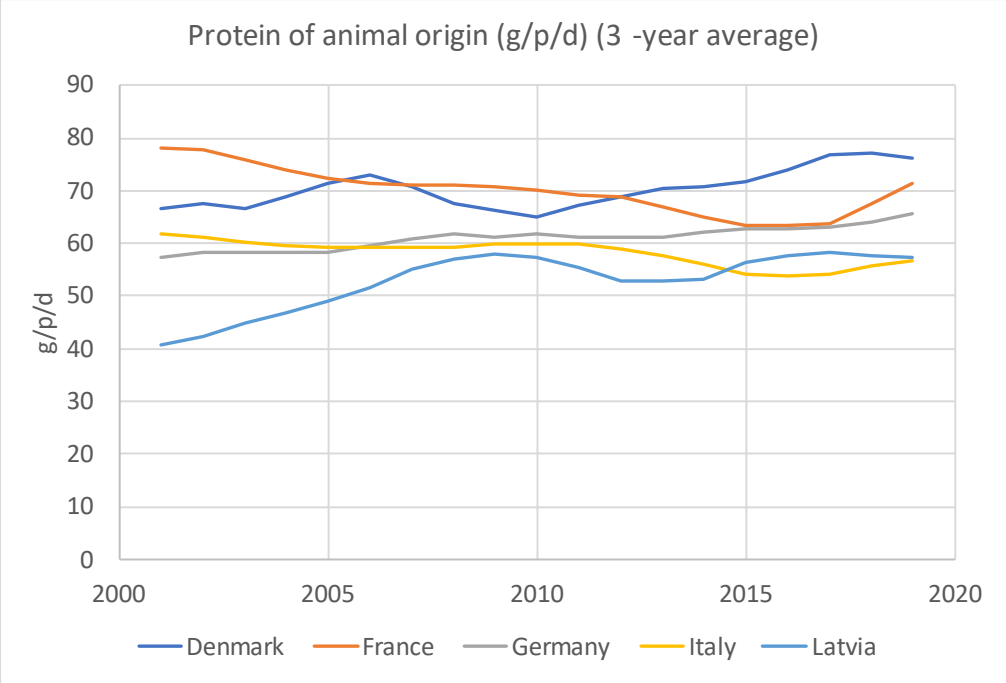

Figure 3: Quantity of protein of animal origin in the 5 countries studied (FAO data)

This is confirmed at least in France, where national statistics show that consumption per capita has increased in the last few years and is higher than in the 2000s (AGRESTE, 2023). Paradoxically, a recent EU-wide survey suggests that flexitarism is spreading and that 73% of flexitarians have changed their dietary lifestyle less than five years ago (ProVeg International, 2021). We did not find why these switches in self-identified diets were not observed in consumption data, however the discussion below on self-identified diet vs. actual consumption might give clues.

Insights from SSH and main socio-demographic variables retained to form population groups

Sufficiency Indicator

For this scenario assumption, the relevant sufficiency indicators are the quantities of food intake from different sources (animal, plant-based). We found data in a French prospective study, SISAE (Barbier et al., 2022), where quantities were derived from a large cohort survey, Nutrinet, in which respondents had to fill in consumption frequency and quantity questionnaires including 264 items (foods and drinks). Data was clustered by authors in six diet groups (see Table 31 in annex).

These groups allowed us to describe the transformation of consumption throughout the trajectory by making assumptions on the evolution of the shares of these diet types.

Another option would have been to consider instead the diet types which people identify to. However, several studies show that self-identification with a diet does not perfectly reflect the quantities of animal and vegetal products consumed (Crouzet & Tayeau, 2021; Rothgerber, 2014; Vinnari et al., 2009). For example, some people reduce meat for health reasons but do not

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consider themselves as flexitarians; others may consider themselves as flexitarians but consume a quantity of meat close to average. We use the notion of attitude-behaviour gap, which has been used in research on sustainable consumption (ElHaffar et al., 2020), to characterise these discrepancies. This gap was also observed in the FULFILL survey data from T3.1, where meat intake frequency was very diverse within each declared diet type (see Figure 4).

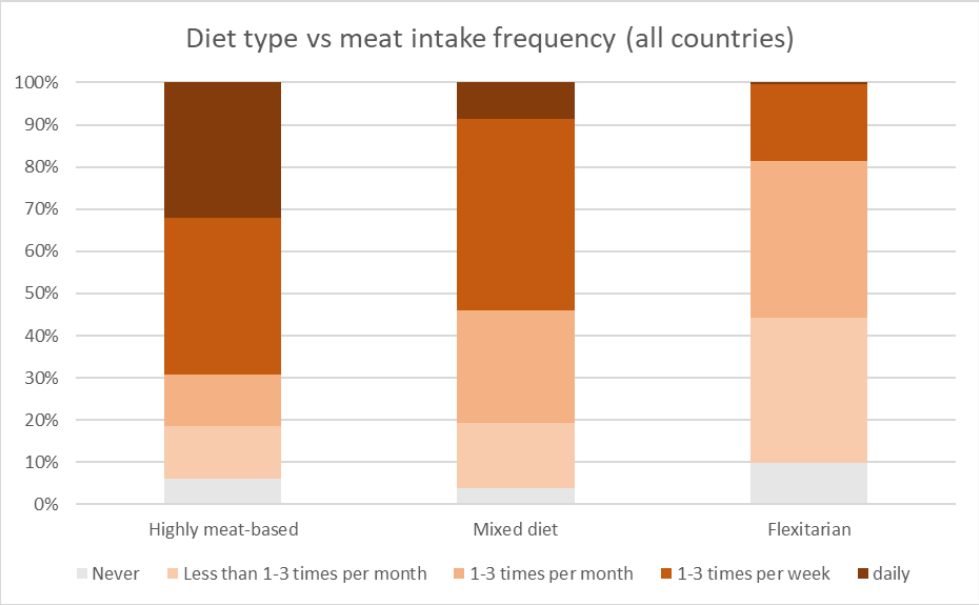

Figure 4: Declared frequency of red meat intake by declared diet type aggregated for the 5 countries (FULFILL survey).

This choice is disputable as self-identified diet type might be more indicative of beliefs than quantities consumed (Perez-Cueto et al., 2022; Rothgerber, 2014), thus more relevant to describe homogenous groups following similar lifestyles. E.g., following data from SISAE the cluster of flexitarians might be quite heterogenous regarding the reasons to consume a given quantity of animal products, thus policies might not apply similarly to the whole group, contrary to what we want to model here. As we did not find a robust way to use self-identified diet types and to deduce quantities from them, we sticked to SISAE data.

The remaining issue regards data for other countries than France, where no such similar survey was produced to the knowledge of our consortium. We observed that the shares of declared meat intake frequency in the FULFILL survey were approximately close to shares of SISAE's diet types for France[2] (see Figure 5), so we used this approximation for the 5 countries (see

Table 33 in annex).

[2] Data for shares was only available in the global report of the whole energy-climate scenario fed by SISAE and did not include shares of pescetarians and vegans: see ADEME, 2021.

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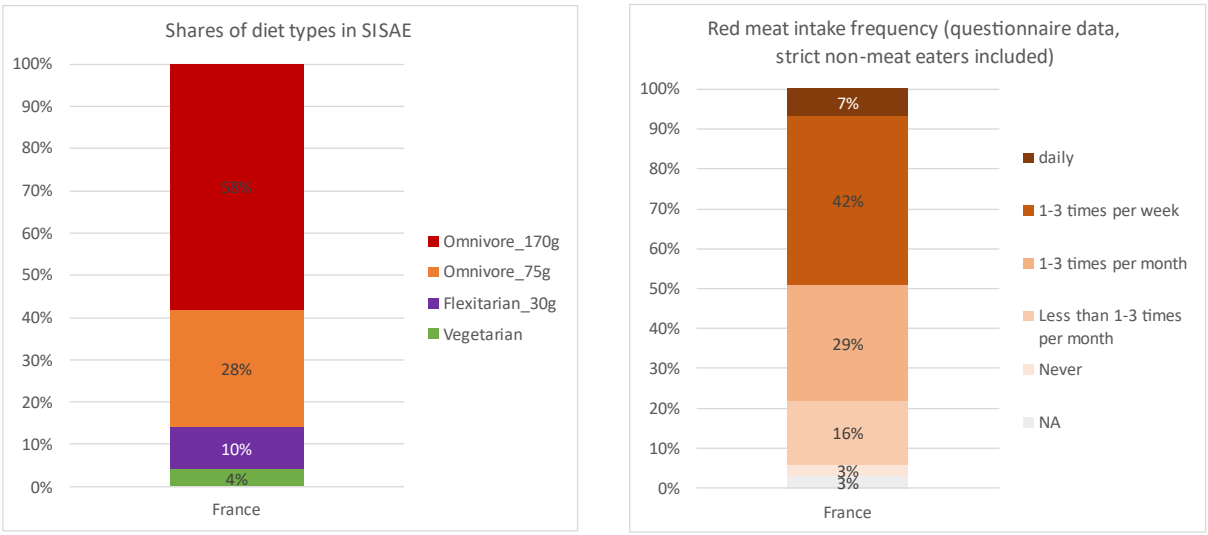

Figure 5: Comparison between shares of diet types in SISAE and declared red meat intake frequency for France (FULFILL survey).

Gender

Differences in meat consumption between men and women and their origin have been well documented (Peeters et al., 2022; Perez-Cueto et al., 2022). These differences appear also in the FULFILL survey data: overall, women identify more with eating plant-based diets and declare eating red meat less frequently (see Figure 6):

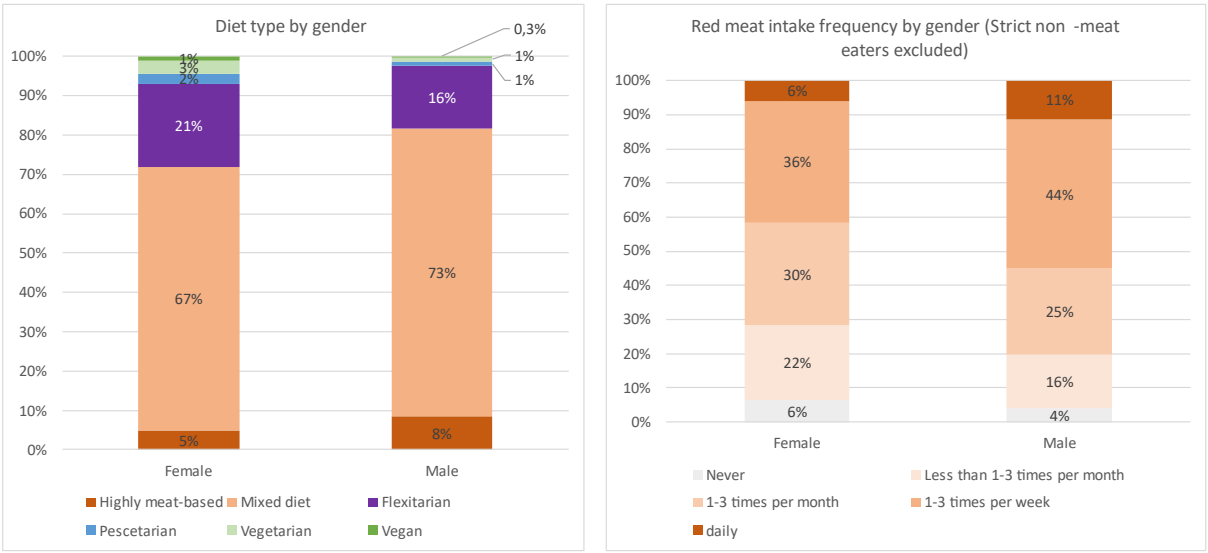

Figure 6: Declared diet type and red meat frequency by gender, 5 countries aggregated (FULFILL survey)

A recent survey found that among respondents, even though on average omnivores may not agree that *"it is not masculine to eat plant-based products"*, women tend to agree less with barrier statements such as *"I think humans are meant to eat lots of animal-based meat"* (Perez-Cueto et al., 2022). We thus assume that gender is a relevant differentiating variable in our approach, as men may react more slowly to policies favouring plant-based diets. This illustrates our rationale for distinguishing groups when it seems that their respective paces of change could be different.

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Age

Age seems to play a role in meat consumption. FULFILL survey data reveals that the share of vegetarians is the highest among people under 30 years old, while the share of people declaring high meat intake diminishes with age (see Figure 7):

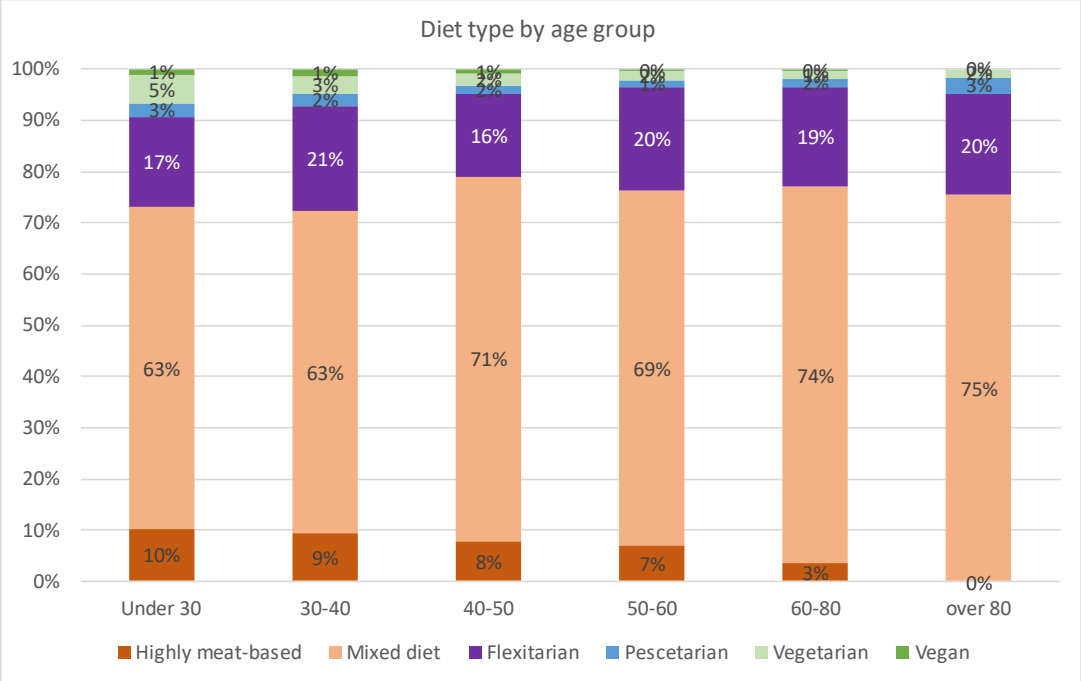

Figure 7: Declared diet type by age group, 5 countries aggregated (FULFILL survey)

This last point could be explained at least partly by health concerns: a survey in France found that 16% of respondents limiting or excluding meat are aged and reducing by constraint for medical reasons (Crouzet & Tayeau, 2021).

Nevertheless this variable was not considered, even though it could have an impact on the pace of change because of the renewal of generations. However, it would have required a population stock model, which we could not set up because of time constraints. Besides, modelling would be complex as people's propensity to stick to a given diet for the rest of their life once adopted is quite uncertain (see discussion section). Lastly, it is difficult to disentangle if differences observed come from an age effect or a cohort effect, or a mix of both.

Guidance target

In the European-wide sufficiency scenario CLEVER (négaWatt Association, 2023), total animal products consumption is about halved. As the scenario reaches the EU climate objectives in terms of carbon budget and neutrality, it fits in the framework of FULFILL, and we suggest it as a reference.

Barriers and enablers crossed with possible policies

Policies were found in Solagro & CAN (2019), and their qualitative potential in Brocard (2023). Barriers and enablers were found in Crouzet & Tayeau (2021) and Perez-Cueto et al. (2022). Other evaluations come from the négaWatt team. Policies mostly consist in support to plant-based alternatives, food industry regulations, availability of plant-based products, taxation, welfare policies on food, education with an attention on gendered roles, and advertisement regulation (see Table 29 in annex).

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Our analysis suggests that policies could at least partially address most barriers and could tap into existing levers, e.g. health benefits (for the detailed analysis, see Table 29 in annex). Generally, policies easier to implement seem also less effective while the most ambitious ones seem on the contrary more impactful (for the detailed analysis, see Table 30 in annex). This suggests a rather gradual path (as opposed to disruptive changes), especially as there are no suggested policies that could drastically and quickly change lifestyles such as bans.

We also note that masculinity norms are specific to men, which confirms the relevancy to distinguish population by gender.

Trajectory for each group: quantification rationale and narrative

To model the evolution of diet type shares, we use two sub-indicators that are estimated at five-year intervals:

- The share of people willing to reduce animal products consumption, to model the spreading of plant-based diets. It does not depend on the diet type, as we do not have data to disaggregate this indicator against diet type.
- The share of people actually changing among the willing ones, to reflect the attitude-behaviour gap and its progressive narrowing thanks to policies. Multiplied by the previous share, it results in a share of people following each diet type that will switch their diet type[3].

To estimate historical shares of these indicators (in 2021), survey data is used. The share of people willing to reduce animal products consumption is extrapolated from data regarding the *length of dietary lifestyle in the Smart Protein Project survey* (ProVeg International, 2021): we deduce that at least 26% of omnivores went flexitarian in the 5 years preceding the survey (see estimation in annex). For the share of people actually changing, we use from the FULFILL survey data the share of flexitarians that declare very low meat intake frequency i.e. less than 1-3 times a month. We assume this to reflect the attitude-behaviour gap, as flexitarians consciously engage in meat reduction, but only a share of them significantly changes. We choose a very low frequency to be conservative.

To estimate the target of prospective shares, we choose to set the indicators' values in 2050 to reach -50% of total animal product reduction (5 countries aggregated) in 2050 (compared to 2021). It is assumed, based on the above policies' analysis, that policies have enough impact to reach this value although this is uncertain. To calculate the overall reduction in animal products consumption for the 5 countries, we calculate total quantities of foods consumed in 2050 by multiplying the food quantities in each diet type by the numbers of men and women following each diet type. Population data is based on Eurostat baseline projection[4] and gender distribution is based on the current one[5] (no evolution is assumed).

Lastly, the pace of change is given by the percentage of impact of policies. It is a percentage of reaching the target applied to both indicators, evaluated at every step according to the full-impact date and qualitative potential of policies (see Table 30 in annex), set at 0% in 2021 and 100% in 2050. It is differentiated by gender: we assume that policies' impact on men is slower, assuming a slight difference between men and women that is cancelled by 2050.

This results in the following shares (e.g. for Denmark in Table 4 for women and Table 5 for men):

[3] This method stems from the one used in SISAE, though here it is disaggregated by a five-year step.
[4] https://ec.europa.eu/eurostat/databrowser/view/PROJ_19NDBI__custom_160151/default/table?lang=en
[5] https://ec.europa.eu/eurostat/databrowser/view/demo_pjan/default/table?lang=en

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Table 4: Modelled sub-indicators regarding diets for women in Denmark

Country	Year	Transition	% impact policies	Share of people willing to reduce animal products consumption	Share of willing people actually changing	Resulting share[6]
Denmark	2025	2021->2025	0%	26%	64%	17%
	2030	2025->2030	15%	30%	68%	20%
	2035	2030->2035	33%	34%	72%	24%
	2040	2035->2040	50%	38%	77%	29%
	2045	2040->2045	75%	44%	84%	37%
	2050	2045->2050	100%	50%	90%	45%

Table 5: Modelled sub-indicators regarding diets for men in Denmark

Country	Year	Transition	% impact policies	Share of people willing to reduce animal products consumption	Share of willing people actually changing	Resulting share[7]
Denmark	2025	2021->2025	0%	26%	48%	12%
	2030	2025->2030	5%	27%	50%	14%
	2035	2030->2035	25%	32%	58%	19%
	2040	2035->2040	45%	37%	67%	25%
	2045	2040->2045	73%	43%	78%	34%
	2050	2045->2050	100%	50%	90%	45%

To define which diets people switch to, we use optimised diets from SISAE (see Table 32 in annex). They are the result of an optimisation model that derives an optimised diet from an existing diet composition. It fulfils nutritional recommendations, reduces animal protein consumption while increasing nutritional density, and is constrained to minimise deviation from the existing diet type foods' consumption (Barbier et al., 2022).

To derive a trajectory, we also assume that people always switch from a diet type (current or optimised) to the optimised one with the closest reduced quantity of animal products (see Table 34 in annex), as change has been suggested to be progressive and in majority towards less animal products consumption (Crouzet & Tayeau, 2021). We will see in the discussion section below that this seems to be controversial though, especially for meatless diets. Exceptions to this rule are people following an optimised vegan or pescetarian diet: respectively because there is no diet with less animal products than the optimised vegan diet, and because we did not look at characteristics of pescetarians, as they represent a marginal share of the population we chose not to make assumptions on this group. Thus, we assume that people who follow these diets stick to them over time.

[6] The resulting share is the share of people willing to reduce animal products consumption multiplied by the share of willing people actually changing.
[7] Idem.

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Results

As expected with the introduction of optimised diets and the method which leads to conserving a share of current diets, there is a diversification of diet types throughout the trajectory (see Figure 28 and Figure 29). Differences between countries are maintained at least partially as a result of applying the same evolution to all countries. Differences regarding gender are also maintained because of the method, although policies could contribute to reduce them (e.g. educational policies could tackle the issue of gendered roles).

We also note that as expected with this method, there remains a share of population eating meat twice a day in 2050, although much smaller than in 2021: 10% of men and 6% of women in 2050 against 50% of men and 36% of women in 2021.

Discussion on the assumption

There are data limitations regarding quantities of foods consumed in other country than France, quantities differentiated by gender, historical data of self-declared diets, and the quantified impact of policies.

In the model, people switch in the same proportions to diets with less meat than to stricter diets, namely vegetarianism and veganism. This could imply for example that switching to zero meat is as easy as reducing it, which may not hold true and seems to be a more profound lifestyle change. However, we did not find data to either confirm or infirm this.

In addition, assuming that people do not go back to an omnivore diet is disputable and one could consider it too optimistic. Stricter diets may indeed be less easy to maintain, which we were not able to model. For example, in the U.S., there are more than five times the number of former vegetarians/vegans compared to current vegetarians/vegans (McArthur, 2014). There might however be mixed findings regarding adherence to diets, as Crouzet & Tayeau (2021) found that only 7% of people with meatless diets and 2% of flexitarians consider going back to an omnivore diet. We assume that suggested policies increase the adherence to more sustainable and healthy diets to the point where abandonment is negligible, which is disputable and would need more investigation through longitudinal studies in a context favourable to plant-based diets.

Using the optimised diets from SISAE in prospective is questionable, as their current adoption among population is unknown. In the context of FULFILL, we chose these diets because they fulfil nutritional recommendations and thus are expected to have more health benefits than current diets. They are assumed to be fostered by certain suggested policies.

Concerning policies, as they are not strict in the sense of bans or quotas for example, they are complex to model and thus their impact is very uncertain. Here we chose an overall target and assumed that suggested policies could ensure at least the achievement of this target. But a preferred option in this context (see methodology section 1.3) would have been to directly model the impact of these policies without any prior objective. Such work would have required further research on the impact of policies, and provided that such data is made available, it would be interesting to carry it out in further research to check whether these kinds of policies are sufficient to reach sustainability objectives.

Besides, policies and their impact horizon were not differentiated according to the different cultural contexts, because of a lack of data and the complexity of finding the balance between assuming a stability of current national contexts and/or their possible respective differentiated evolution when applying the same policies.

Regarding equity, we lacked data and time to deal with this issue that is nevertheless at the heart of sufficiency. Data of food quantities distribution within each country (equity between individuals) would have been a starting point to suggest a convergence of quantities in a

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consumption corridor[8] that is left to be determined (it could for example be based on nutritional recommendations). Even though it was not modelled, some suggested policies aim to increase access of those in need to healthy food. Further research could look at how such policies could impact current inequalities in food access. This issue of equity between countries is more broadly discussed in section 3.6.

2.2. Cohousing

Table 6: Summary of the construction of the quantified trajectory for the "Cohousing" scenario assumption

Perimeter of study	Cohousing is spreading as a housing option.
Indicators	Square metres per person (m²/cap) saved thanks to cohousing.
Past trends	Growth that is not quantifiable, lack of data.
Population groups	N/A
Guidance target	See *"Sharing space in housing"* scenario assumption (section 2.3).
Policies	See *"Sharing space in housing"* scenario assumption (section 2.3).
Main elements underlying the quantified trajectory	N/A
Main results	N/A
Discussion	See *"Sharing space in housing"* scenario assumption (section 2.3).

Perimeter of study and relevant indicators

Between 1990 and 2018, energy efficiency gains in buildings in the EU were almost completely offset by increases in floor area (EEB & OPENEXP, 2021). Thus, sufficiency regarding living space is an indispensable lever in decarbonisation strategies. In this sufficiency scenario assumption, we look at the possible spreading of cohousing and its potential impact on living space per capita. Because of important data limitations, this scenario assumption was not quantified and only studied qualitatively.

Shared housing may take different forms and the definition of each form is not trivial (Clark, 2021). The UK Cohousing Network gives a definition of cohousing communities: *"Cohousing communities are intentional communities, created and run by their residents. Each household has a self-contained, private home as well as shared community space. Residents come together to manage their community, share activities, and regularly eat together."*[9]

Cohousing distinguishes from regular house/flat sharing because it is created and managed by an *"intentional community"*. Contrarily to house/flat sharing, it is resident-led (Clark, 2021). Members of the community *"work cooperatively to create a lifestyle that reflects their shared core values (Ibid)"*. In cohousing projects studied in T3.2, "*Community is an important motivation for many participants. This community can refer to the ideal of a different lifestyle, with a transformative element" (FULFILL, 2023d).*

[8] We use the definition of a consumption corridor from the CLEVER scenario (négaWatt Association, 2023): a consumption range for a given indicator, *"bounded by two thresholds [...] A lower threshold based on '*decent living'" and *"an upper threshold representing a level of services compatible with a 1.5°C global warming trajectory".*

[9] https://cohousing.org.uk/about-cohousing-2/

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Cohousing may save more than just living space per capita and supports other sufficiency habits: "*Living in cohousing […] automatically increases the opportunities of sharing goods and facilities. Most cohousing projects include the (explicit or implicit) sharing of tools and activities"* (FULFILL, 2023d). Thus, studying spillover effects seem significant for this scenario assumption. These effects are less systematic for more standard forms of house/flat sharing. The angle of the "sharing space in housing" scenario assumption is different than this one as it investigates only changes in square meters per capita (m²/cap) and considers any form of shared housing (including cohousing) that can reduce m²/cap (see section 2.3). It only looks at one indicator, whereas here the more systemic effects are considered.

Macro data analysis, past and present trends

To our knowledge, no data has been published at a national level in the 5 countries studied to quantify the share of dwelling considered as cohousing, since cohousing communities or buildings are not registered systematically. The only country in which we found related data collected by a public entity is Switzerland, where cooperative housing represents about 3% of buildings (OFS, 2024). But it is uncertain if this type of housing can always be considered cohousing, and if there exists cohousing that does not have a cooperative status, and to which extent.

Clark (2021) listed existing records of cohousing projects by country. This suggests that cohousing is niche, although probably the number of projects is underestimated for some countries. For example, in France, a collaborative website census more than a thousand projects (Oasis and HPF, n.d.).

No data on the evolution of cohousing has been found, although it seems that cohousing is growing, at least from the number of projects starting or looking for more inhabitants in the Oasis and HPF database.

Insights from SSH and main socio-demographic variables retained to form population groups

Bigger households' carbon footprint per capita is on average lower than smaller ones, thanks to economies of scale (Ivanova & Büchs, 2020). This suggests that cohousing households would have a lower carbon footprint than average. It was found that this holds true for a few household communities in UK (Clark, 2021).

The interviews conducted in T3.2 shows that cohousing inhabitants reduce their energy or carbon footprint in several ways (FULFILL, 2023d), by:

- Sharing spaces
- Engaging in energy-efficient renovation work: *"people involved in such projects often have ecological concerns and the fact of pooling financial resources through collective acquisition facilitates the implementation of ambitious renovation work and/or high-quality construction"*
- Paying attention to energy demand and engaging in sufficiency practices: *"some respondents have mentioned avoiding the use of electronic devices or limiting it (water boiler, dishwasher, washing machine, TV and AC)."*
- Sharing tools and appliances, which reduces the ownership rate (see also the "sharing products" scenario assumption)
- Adopting plant-based diets: *"many interviewees have less carbon-intensive diets. Many of them mention being vegetarian or vegan, though it is not a general rule in the initiatives under study"*.
- Reducing packaging: *" Practices of zero-waste and/or bulk products are also common amongst the participants"*.

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- Sharing cars: *"Having a routine for working collectively facilitates car-sharing, which are part of one cohousing initiative in France and two in Italy"*
- Reducing air travel: *"Some respondents in France also mention their effort to exclude plane use or to reduce it."*

All in all, carbon calculator results from respondents engaged in intentional communities show that "*their intention to pursue a sufficiency-oriented lifestyle does have impact on their carbon footprint, though in various ways".* Findings from T3.2 are consistent with previous research mentioned above, although they must be considered with caution as sample size is very small.

However, for our purpose here, there are several limitations. First, we would need data regarding quantified sufficiency indicators to compare cohousing community members to a reference (e.g. m²/cap, but it could be other indicators reflecting other types of sufficiency practices) and not emissions, as these are not a direct measure of sufficiency. For example, some communities have a lower carbon footprint – at least partly – because of energy efficient infrastructure and non-fossil fuelled systems (Clark, 2021; FULFILL, 2023d). This is not negligible as *"Heating is the most impactful sector, especially in Denmark and Latvia*". But this is out of the scope of sufficiency and the carbon footprint does not enable to disentangle sufficiency, efficiency and energy carrier respective effects. To our knowledge, a more comprehensive study looking at sufficiency indicators in cohousing communities in different EU countries is yet to be done.

Also, we do not know how representative of cohousing communities these practices are, and how consistent: there are important differences between respondents, sectors and countries.

Another important limitation is the issue of causality. We do not know whether cohousing is rather a cause of adopting a sufficient lifestyle, or the consequence. Looking at a reduction in energy or carbon footprint is complex because it depends on which reference it is compared to. To complete existing results, it could be interesting to compare people living in cohousing and in other forms of habitat on the basis of sufficiency indicators.

Looking at mobility consumptions of these communities could be complex, as there could be rebound effects. It is possible that some people move away from cities to more rural areas to access cohousing and eco-village projects, thus increasing their travel distances (FULFILL, 2023d).

Regarding social groups, we did not find robust data regarding profiles of people participating in these communities, so this would be an issue if we were to implement the methodology suggested in this report. Another unsolved issue is: can anyone participate in cohousing? To build a trajectory, we would need to know if there are such limitations, although cohousing spread would be probably limited primarily by the inertia of the building stock.

Barriers and enablers crossed with possible policies

We considered that barriers, enablers and policies discussed for "*Sharing space in housing*" apply for cohousing and refer to the corresponding part in section 2.3.

Trajectory for each group: quantification rationale and narrative

Because of data limitations mentioned above, we could not derive a trajectory for this sufficiency assumption. Cohousing however is included as one of the sharing space options in the "*Sharing space in housing*" scenario assumption (section 2.3).

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2.3. Sharing space in housing

Table 7: Summary of the construction of the quantified trajectory for the "Sharing space in housing" scenario assumption

Perimeter of study	Reducing excessive space consumption by developing shared housing for the target population.
Indicators	Square metres per person (m²/cap) saved by adopting a shared housing option.
Past trends	The number of people per household decreases while m²/cap increase.
Population groups	Target: people aged over 65 and in households of 1 or 2 people.
Guidance target	None.
Policies	Incentives to move to smaller or shared dwellings, and support measures to shared housing. Impact: mostly long-term, limited.
Main elements underlying the quantified trajectory	Shares of households in the target category and with a living space above 50m²/cap adopts different forms of smaller or shared housing. The evolution of these shares, depending on housing type, is either based on a target or a growth trajectory inferred from surveys.
Main results	Percentage reduction of average m²/cap for the target category: -9% to -14% depending on the country.
Discussion	Restrained perimeter not encompassing other sharing practices; gender and income not taken into account; data limitations for countries other than France; bias on living space data in the FULFILL survey; limitations due to not modelling building and population stocks; issue of not taking into account the housing crisis and real estate economic mechanisms.

Perimeter of study and relevant indicators

As said in the *"Cohousing"* scenario assumption, sufficiency regarding living space is an indispensable lever in decarbonisation strategies. In this assumption, we look at the possibility to mainstream shared housing in different forms to reduce under-occupied housing.

Different forms of shared living have been described thoroughly in Clark (2021). Here, we do not favour a particular category and consider shared housing in an aggregate manner including cohousing, community living, house-share or co-living. Ecovillages also fall in the perimeter; however, it seems they can overlap with cohousing, and it is not certain that they enable reductions in space consumption.

What is regarded as under-occupied has to be defined and is prone to debate. Eurostat gives a definition according to the number of rooms[10]. Unfortunately, the distribution of this indicator is missing, and data was missing to cross it with information on the average square metres per room, therefore we use instead the FULFILL survey data, and assume a threshold of living surface area per person.

The sufficiency indicator that we use is the number of square metres per person (m²/cap) saved by adopting a shared housing option.

[10] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Under-occupied_dwelling

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Macro data analysis, past and present trends

In the last decade, the average number of people per household has decreased in most EU countries, mainly due to an increasing number of single-adult households[11]. In parallel, average m²/cap increased in most EU countries between 2000 and 2018 (EEB & OPENEXP, 2021); and in 2021, 33% of the EU population lived in an under-occupied home[12].

These trends are not going in the direction of sufficiency. Without actions to reverse them, it does not seem likely that lifestyles will change towards more sufficient practices.

Insights from SSH and main socio-demographic variables retained to form population groups

SSH provide reasons explaining the decrease in number of people per household, such as increase in divorces, lower fertility rates, decreasing number of multi-generational households, need for individual autonomy, etc. (Ivanova & Büchs, 2020, see section 4.3). These social factors are not likely to be the target of sufficiency levers and may even foster well-being and/or equity (e.g. female emancipation). But excessive space consumption must be tackled in the context of sufficiency. Sharing housing space voluntarily may offer a solution that is sustainable (Ibid) and could increase well-being, although the net benefit of engaging in community living versus losing privacy – at least in some rooms – needs to be discussed and may be subjective and influenced by cultural norms (Put & Pasteels, 2022).

To simplify this scenario assumption, as household dynamics are complex, we choose to focus on a part of the population that we suppose to be the most relevant with regard to the potential reduction in m²/cap and the benefits in terms of well-being: older people (here aged over 65 for the practical purpose in T6.1 of matching Eurostat categories) either single or in couple. Among them, only those who find themselves with significant spare space – typically because their household size (expressed in persons per household, noted p/hh) has reduced because of children leaving the dwelling, but potentially for other reasons as well – are expected to reduce m²/cap in this scenario assumption. What is considered spare space is defined thereafter.

The identification of this sociodemographic profile comes from a survey where respondents were asked if they considered their living space fit their needs, and under which conditions they would be willing to move for a smaller dwelling (Thomas, 2017). Respondents declaring that they think their flat is too big had on average a living space of 78 m²/cap, typically owned the flat, were older (54% older than 60), and were either single or in couple.

We find very similar results when extracting data from the FULFILL survey, e.g. respondents who declared that they *"could do with less space"* declared an average living space of 80 m²/cap, while the average declared living space for all respondents is 54 m²/cap:

[11] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Household_composition_statistics

[12] https://ec.europa.eu/eurostat/databrowser/view/ILC_LVHO50A__custom_10916002/default/table?lang=en

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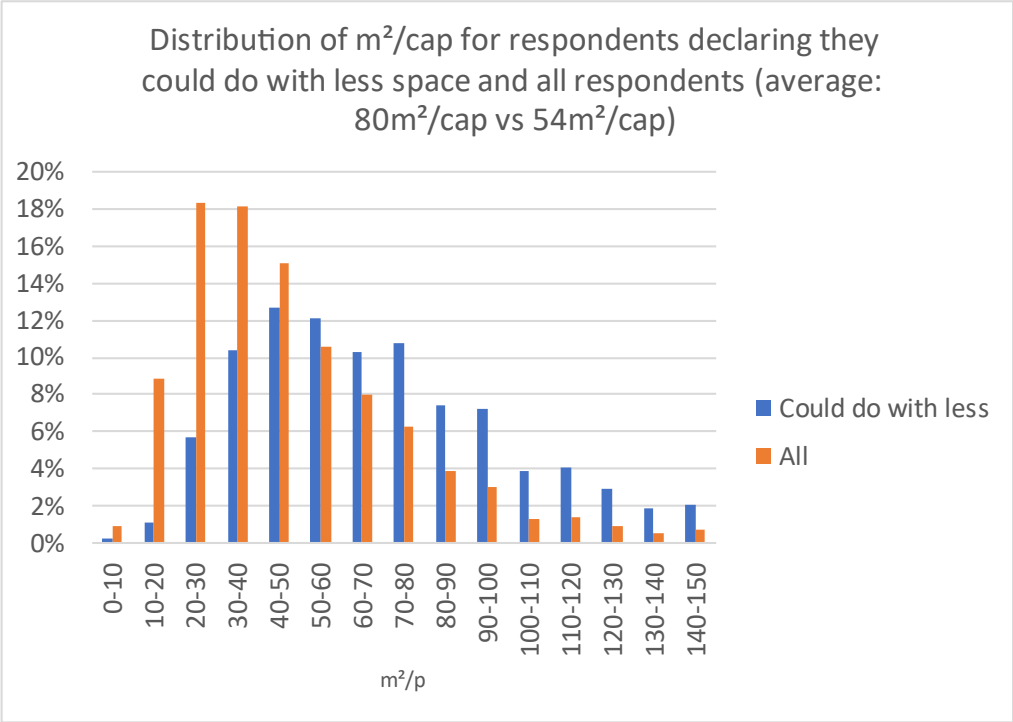

Figure 8: Distribution of m²/cap for respondents declaring they could do with less space and all respondents (FULFILL survey data)

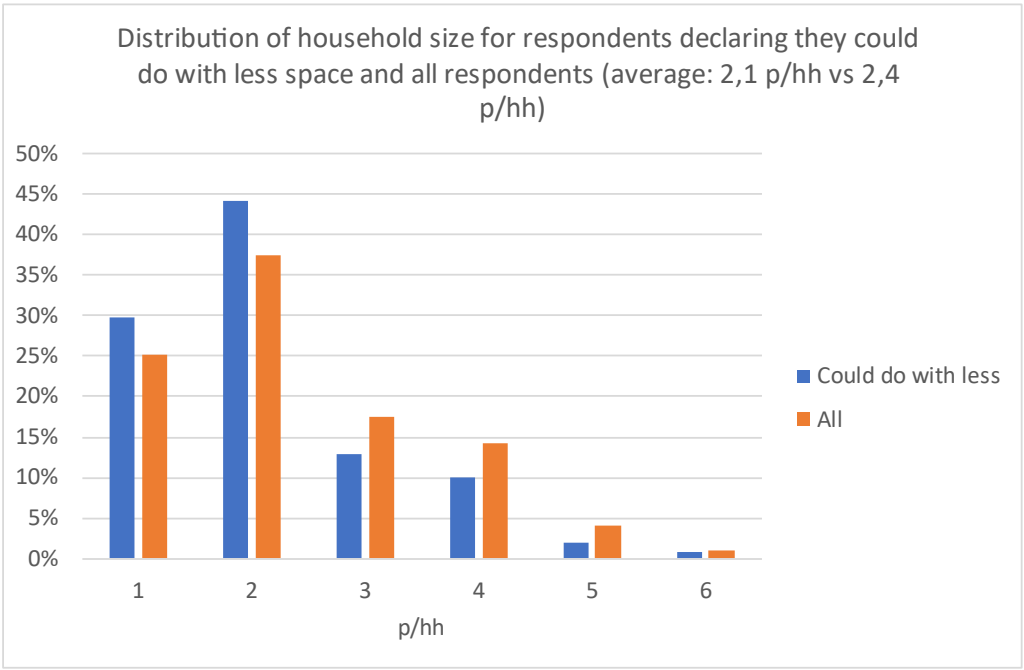

Figure 9: Distribution of household size for respondents declaring they could do with less space and all respondents (FULFILL survey data)

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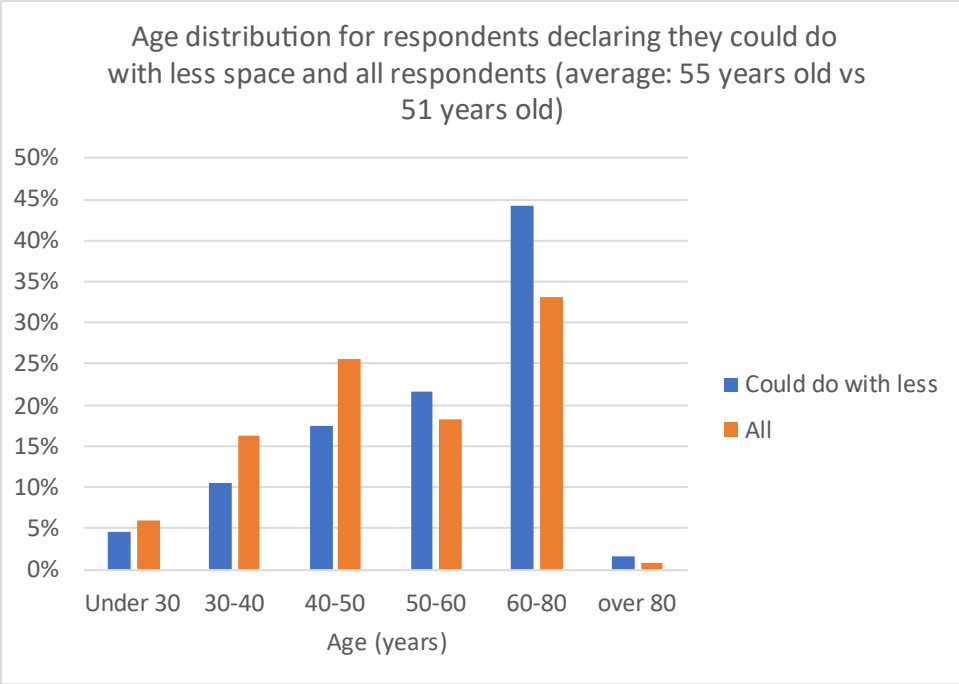

Figure 10: Age distribution for respondents declaring they could do with less space and all respondents (FULFILL survey data)

Even though the mentioned averages are close to those of Thomas (2017), choosing this sociodemographic profile seems a simplified approach as FULFILL survey data also shows that there is a large diversity of what is considered extra-space and a diversity of ages and household sizes.

To go further, targeting overconsumption of space in other categories would need more research: e.g. a couple can live in a large dwelling in expectation of having children, students living in small spaces may consider flat sharing to increase their living space to the point m²/cap increase, etc.

Health benefits of living in cooperative shared dwellings for older people are likely positive as these environments have been observed to favour "*well-ageing*", at least in France (PGI, 2018).

Barriers and enablers crossed with possible policies

Policies, barriers and enablers, suggestions were found in Karlen et al., 2022, Thomas, 2017 and FULFILL (2023d, 2023f). Suggested policies mostly consist in incentives to move to smaller or shared dwellings, and support measures to shared housing (see Table 35 in annex).

Barriers are on several levels: at the macro level we can list the low vacancy rate and the lack of adequate supply; at the meso level there is the lack of support or administrative burden; at the micro level we can name the concerns for privacy and change in routines, although individuals are also influenced by cultural expectations of *"housing careers"* and homeownership (Put & Pasteels, 2022), socio-cultural barriers that can be categorised as macro.

Our analysis suggests that the proposed policies could only partially address existing barriers and that benefits of community living may not be convincing enough for everyone, thus calling for a trajectory of moderate change (see Table 35). Policies proposed seem to be long-term and their impact is uncertain as we did not find its evaluation in literature (see Table 36).

Trajectory for each group: quantification rationale and narrative

In our approach, two parameters are needed to calculate the reduction in m²/cap: a threshold in m²/cap above which people are considered living in under-occupied housing; and an average value of m²/cap per alternative.

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Threshold

Defining a threshold from which space consumption is considered excessive is complex. As seen previously in FULFILL survey data, it is quite subjective. In the absence of a common and shared definition, we propose values for this threshold. To do so, we refer to the current average m²/cap in Denmark which is around 50 m²/cap and is one of the highest values in EU (négaWatt association, 2023), to reflect a certain level of comfort. We retain a threshold of 50 m²/cap for one-person households, and of 40 m²/cap for two-person households to account for some mutualisation of rooms.

We calculate m²/cap with FULFILL survey data to compare them with this threshold. Values were declarative thus might be biased (see discussion section). Extreme values below 5m² and above 1000m² were removed.

Surface area per capita for each alternative

Lastly, we define average m²/cap for each of the housing alternative. These values are assumptions from négaWatt, as no data was found to estimate them. They are the same for the 5 countries, as a matter of equity and as we did not find reasons to differentiate them.

Table 8: Average square metres per capita for each housing alternative considered, depending on the degree of urbanisation and household size

Household size	m²/cap per alternative	Cities	Towns and suburban	Rural
1	m²/cap smaller dwelling	40	45	50
	m²/cap sharing with private bedroom	30	30	30
	m²/cap sharing with private apartment	50	50	50
2	m²/cap smaller dwelling	35	40	45
	m²/cap sharing with private bedroom	30	30	30
	m²/cap sharing with private apartment	50	50	50

Then, to model the switch to more sufficient housing alternatives for the considered category – disaggregated by household size (one or two persons) and urban type (cities, towns and suburban, rural) thanks to FULFILL survey data –, several sub-indicators were used:

- The share of the target category engaging in intergenerational cohabitation, i.e. adding a person to the household.
- The share of the target category moving to a smaller dwelling or splitting their current dwelling, thereby reducing its m²/cap.
- The share of the target category moving to a shared dwelling, thereby reducing their m²/cap. We distinguish 2 sub-alternatives, with different assumptions for the resulting m^2/cap: having a private bedroom only or a private apartment.

The first step is to derive historical shares for each alternative from surveys.

- Intergenerational cohabitation: we did not find any data, so 0% is assumed.
- Moving to a smaller dwelling or splitting dwelling: we extrapolated this share from the FULFILL survey data. We assume it corresponds to the share of the category that are tenants (already incentivised to move to pay a smaller rent) and declare they could

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do with less space. On average this represents 3% of the target category, which is marginal, as shown by Thomas (2017).

- Shared dwelling: in France, 30,000 people at least are estimated to live in independent living residences (DREES, 2023). We extrapolate that if they are all 60 years old or more, it converts to 0,17% of the target category. We assume that 80% of them are single-person households and the rest are two-persons households, according to a survey conducted by Nowik et al. (2016). For single-person households, we assume arbitrarily that they are split in equal parts between shared housing with private bedrooms and shared housing with private apartments. For two-persons households we assume that they only live in shared housing with private apartments as it is more suitable for them (Ibid).

Then, for prospective sub-indicators, two methods are used, based on available data:

Firstly, for intergenerational cohabitation and moving to a smaller dwelling/split dwelling, we derive potential targets from surveys, deducing them from questions on the willingness to change. We assume the potential shares for intergenerational cohabitation and moving to a smaller dwelling or splitting dwelling to be respectively 20% (Nestenn/IFOP, 2019) and 25% (Karlen et al., 2022; Thomas, 2017).

Then a percentage to reflect an attitude-behaviour gap is applied to suggest that the potential cannot be fully reached with proposed policies. For example, one of the conditions for people to move is to stay in the same neighbourhood (Ibid). This cannot be guaranteed, even though we can imagine that shared options could spread to meet at least partially this requirement. We also suggest that it could be more difficult in less dense areas, so this percentage is differentiated by urban type, and was assumed by négaWatt, since we did not identify any literature on this subject. Lastly, we did not identify reasons to differentiate by household size for these shares.

This results in the following shares:

Table 9: Prospectives shares for intergenerational cohabitation and moving to a smaller dwelling/splitting dwelling

		Potential			**Attitude-behaviour gap**			**Resulting share : 2050 target**[13]		
Year	Alternative type	Cities	Towns and suburban	Rural	Cities	Towns and suburban	Rural	Cities	Towns and suburban	Rural
2050	Intergenerational cohabitation	20%	20%	20%	40%	20%	5%	8%	4%	1%
2050	Move to a smaller dwelling/split dwelling	25%	25%	25%	40%	25%	25%	10%	6%	6%

Regarding the pace of change, as suggested policies are progressive, the trajectory between historical share and target share is set as linear.

Secondly, for shared housing, shares of the target category moving to a shared dwelling (shared space with private bedroom / shared space with private apartment) were modelled by using the projected growth of independent living facilities in France mentioned in Kuhn Lafont and Troutot (2022) – +330% to +440% by 2030. We assume that this growth translates to a similar growth of households living in shared housing. This seems conservative as this is only one of the many forms that shared housing can take. Then we assume this growth to be +385% every 10 years

[13] The resulting share is equal to the potential multiplied by the attitude-behaviour gap.

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(middle of the range) for one-person households, and +440% every 10 years for two-person households (top of the range)[14]. This applies to all countries, relying on the development of a variety of offers. The resulting trajectories are shown in Figure 11:

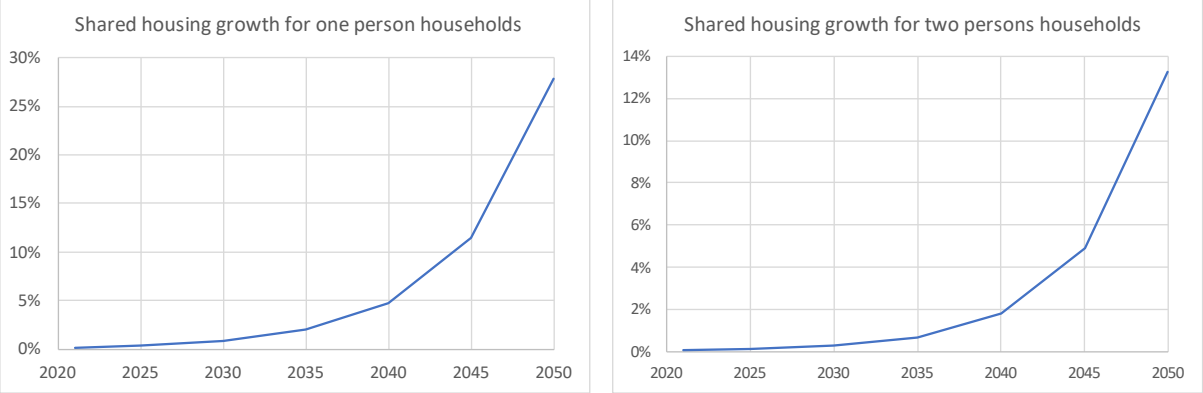

Figure 11: Growth of the shares of the target category opting for shared housing, for one and two-person households

Results

The average reduction in m^2/cap is calculated compared to 2021 (year of the FULFILL survey data), see Figure 12. The average reduction in m^2/cap for the target category (including households below the threshold) falls within the range of 9% to 14%, and new average m^2/cap falls between the range of 47m^2/cap to 73m^2/cap (see Figure 13). Differences between countries come from differences in the distribution of m^2/cap (e.g. a country like Denmark, where almost all the households in the category are above the threshold, has the largest reduction), and differences in the distributions of households according to urban type and household size. The shape of the curve reflects the construction of the evolution of shared housing (geometric growth).

[14] Options for two-person households are quite scarce for now, especially because shared housing is mostly independent living currently. With other emerging forms of sharing that are more fit for these households such as cohousing, the growth of these options is modelled to be higher i.e. the top of the projected range.

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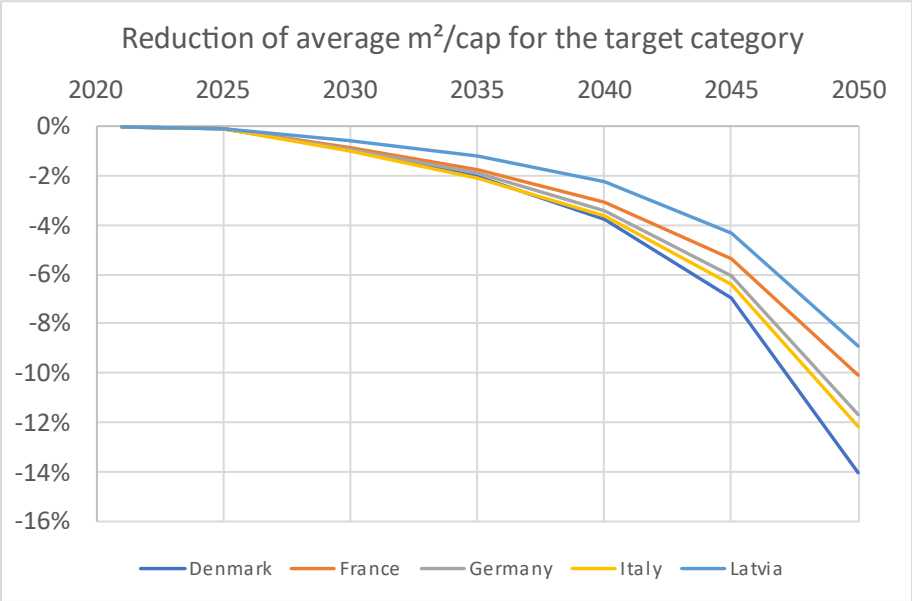

Figure 12: Reduction in average m²/cap for the target category for the 5 countries

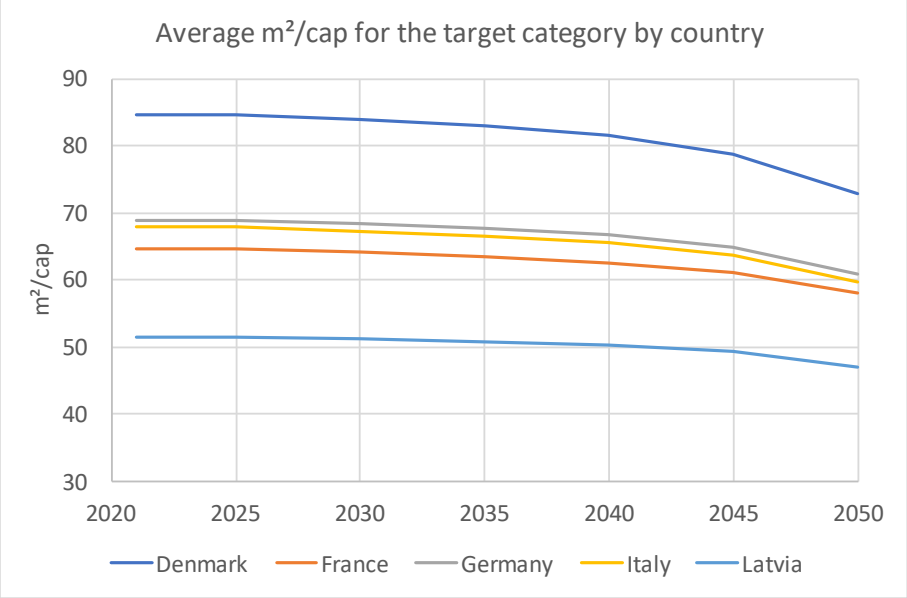

Figure 13: Average m²/cap for the target category in the 5 countries

To translate these reductions in m²/cap for the target population into reductions in m²/cap for the whole population, this work would have to be completed by a quantification of the proportion of the target population relatively to the total population. This calculation will be carried out in the following T6.1 (FULFILL, 2024).

Discussion on the assumption

There were several data limitations: surveys used were mostly conducted in France and we could not find similar surveys in other FULFILL countries. We assumed that these findings were transposable to other countries, although this remains to be confirmed. Data on m²/cap in existing shared housing, disaggregated by housing alternative, could have been useful to refine m²/cap of alternatives.

There is likely a bias in the FULFILL survey answers to the question: "*What size is the living space of your 2021 dwelling?":* indeed, multiple of 5 and 10 are over-represented in the answers,

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suggesting that respondents gave an approximate estimation which could bias the results of the assumption in one way or another: see Figure 14.

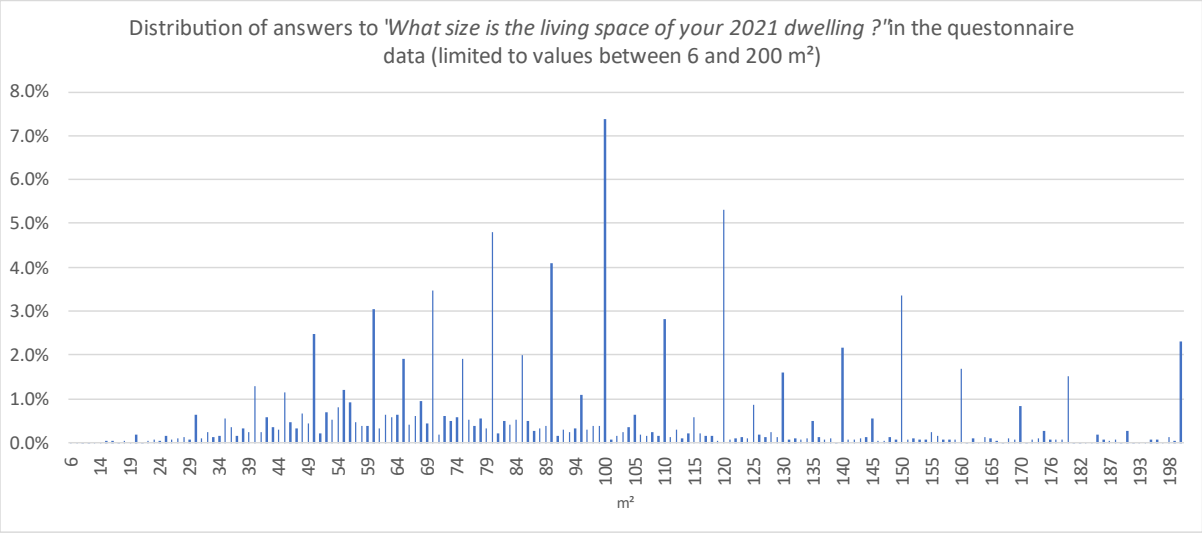

Figure 14: Distribution of answers to "What size is the living space of your 2021 dwelling?" in the FULFILL survey data (limited to values between 6 and 200 m²)

Another limitation is that there is no modelling of the building or population stocks, which makes it impossible to describe changes in under-occupation and overcrowding, or transfers of buildings between households of different sizes. We would recommend that consideration be given to using such models in order to refine the scenario assumption to see how these policies could contribute to sufficiency by reducing overcrowding, or to infer the reduced need for new buildings thanks to shared housing.

The chosen threshold in square metres per capita above which people are considered living in under-occupied dwellings may not be realistic. To refine it, it could be interesting to look at cooperatives that adopted occupancy rules that include proposing inhabitants a smaller home when their household size reduces (Karlen et al., 2022); or try to estimate which rooms are necessary and of which size in relation to household size. It could be useful to gather data on the size of different types of rooms to develop a vision of what is deemed necessary. For intergenerational cohabitation, it would be possible to add more than one person in the dwelling in some cases. We did not model this and checked that this parameter does not carry much weight compared to others: less than a percent of reduction in m²/cap at most.

Housing in not affordable for everyone[15], which this assumption does not address, along with the overcrowding issue[16]. There could be some adverse social consequences, depending on which solution is favoured: for example, promoting cohousing in order to access more affordable housing seems socially positive, but encouraging the split and sell of existing housing might end up in raising the prices even more. The social impacts of different levers should be carefully evaluated for each of them.

We did not investigate the issue of vacant or rarely occupied dwellings, although they constitute an opportunity to avoid new buildings and to provide affordable housing (FEANTSA & Fondation Abbé Pierre, 2016): this could be studied as a scenario assumption in its own.

Regarding policies, there are uncertainties from an economical point of view, as we cannot model how the spreading of shared housing and the setup of incentives would interact with the real estate market. Further research by economic modellers could investigate ways of ensuring that shared housing is the most affordable option and how high the incentives need to be to reach ambitious objectives in terms of reducing as much as possible under-occupied housing.

[15] https://ec.europa.eu/eurostat/cache/digpub/housing/bloc-2b.html?lang=en
[16] In 2021, 17% of the EU population lived in an overcrowded home: https://ec.europa.eu/eurostat/cache/digpub/housing/bloc-1c.html?lang=en

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Regarding the choice of sociodemographic variables, the choice of targeting people over 65 years old is questionable and could be perceived as discriminating. Even if, in reality, most under-occupied housing is owned by people aged over 65, it might be preferable for the narrative to target all under-occupied housing more systematically. Income was not included to form groups, even though it probably plays a role, e.g. tenants in higher income categories are less willing to move (Ibid). Gender was not included as well, because the reasoning is done primarily at the household level, while it could be an important factor that was not investigated thoroughly here. For example, Eurostat data showed that women of more than 65 years old are living alone more often than men. Also, the different kinds of levers are melted here (cohousing, house split, moving out…) whereas they may cover very different realities, with different sociodemographic trends, and policy levers.

Finally, other forms of sharing that could be fostered by sharing a dwelling were not considered to restrain the perimeter of the assumption, whereas multiple sharing practices were observed when investigating cohousing in previous FUFILL research at the micro level (FULFILL, 2023d).

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2.4. Sharing products

Table 10: Summary of the construction of the quantified trajectory for the "Sharing products" scenario assumption

Perimeter of study	Sharing washing machines, either peer-to-peer, in communal laundries (inside a building) or in laundromats
Indicators	Ownership rate of washing machines
Past trends	High ownership rates, except for DK, where communal sharing is well developed. Present peer-to-peer sharing assumed to be close to 0% in all countries.
Population groups	3 age groups: young households (from 18 to 24 years), average households (from 25 to 54) and older households (above 54)
Guidance target	1/3 of the population sharing a washing machine is considered a ceiling (except for DK)
Policies	EU legislation enforcing availability in new buildings & deep renovations (e.g. EPBD); Subsidies and legal framing to facilitate installation in buildings and neighbourhoods; Support to sharing apps & platforms; Facilitate remuneration schemes between peers; Adding laundry to public service facilities; etc.
Main elements underlying the quantified trajectory	Young households most eager to share. Average households less interested in sharing. Older households reluctant to peer-to-peer sharing, but increase of communal sharing practice through shared housing facilities. Sharing practices develop slowly till 2030, then more rapidly as they go mainstream and infrastructures become adapted (communal laundries). Share of laundromats constant until 2050.
Main results	Similar ownership rate above 70% in 2050 for all countries except DK (63%). Peer-to-peer sharing is practiced by only around 13% of the population in 2050; communal sharing raises to 25% in DK and between 15 and 20% in the 4 other countries. The trajectory over the 5 countries translates into a 20% smaller stock in 2050.
Discussion	Relatively basic subdivision of the population. Need to be analysed through the gender lens. Peer-to-peer sharing is the most uncertain practice in the absence of hard legislation. Communal laundry rooms and services are more promising, however, the implementation and development require time and urgent policy decisions.

Perimeter of study and relevant indicators

Sharing practices and the sharing economy are often associated with sufficiency, since they may lead to using less equipment and resources in principle. However, they might also stimulate new consumption habits and lead to the opposite, depending on the conditions (Meshulam et al., 2024).

There are varied ways in which products could be increasingly shared, through e.g. peer-to-peer sharing with relatives and neighbours, more organised (potentially remunerated) sharing, rental/leasing services, etc. There are also many candidate products and equipment that could be usefully shared (cars, clothes, tools, appliances, books, games, etc.). They all have specificities that make it impossible to consider a general sharing assumption that would cover them all.

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After due consideration, the choice has been made to cover one iconic example and **washing machines** have been picked up, for three main reasons: the availability of data, the importance of the environmental impact of this product (both at production and usage stage), and the significance of sharing such a product in terms of lifestyle (as it requires a non-trivial effort and relates to several social norms of comfort, cleanliness, intimacy, etc.).

The main indicator for this assumption is the **ownership rate** of washing machines. It is believed to be a good indicator since households who do not own a machine either wash their laundry by hand (probably a tiny fraction of the population in the focus countries) or use a shared machine one way or another. Three main types of sharing are covered:

- Peer-to-peer (direct sharing between households)
- Communal (use of common machines within a laundry room in a building)
- Laundromat (use of machines in an automatic laundry shop)

Macro data analysis, past and present trends

National statistics on washing machine ownership are available (see Table 11).

Table 11: Latest national statistics on washing machines ownership rates for the 5 FULFILL countries

Country	Year	Value	Source
Italy	2022	97%	Statista
France	2021	96%	GIFAM
Germany	2022	96%	Statistiches Bundesamt
Denmark	2022	81%	Danmark Statistik
Latvia	2020	92%	Official Statistics Portal

It is worth noting that Denmark (and Nordic countries in general) is leading in terms of communal sharing, as it has been a national tradition to organise certain buildings with a shared laundry facility (often for poor populations).

It is assumed that at present peer-to-peer sharing is close to 0% in all countries. The remaining share of the population not owning a machine is essentially communal sharing in Denmark and laundromat users in the four other countries.

Insights from SSH and main socio-demographic variables retained to form population groups

Respondents to the quantitative survey in FULFILL (2023c) were asked whether they could consider borrowing products from friends or acquaintances (without details on the product type). The answers show a significant variation between gender and age groups, and less differentiation based on household size or income. They are shown in Figure 15, which covers all five countries.

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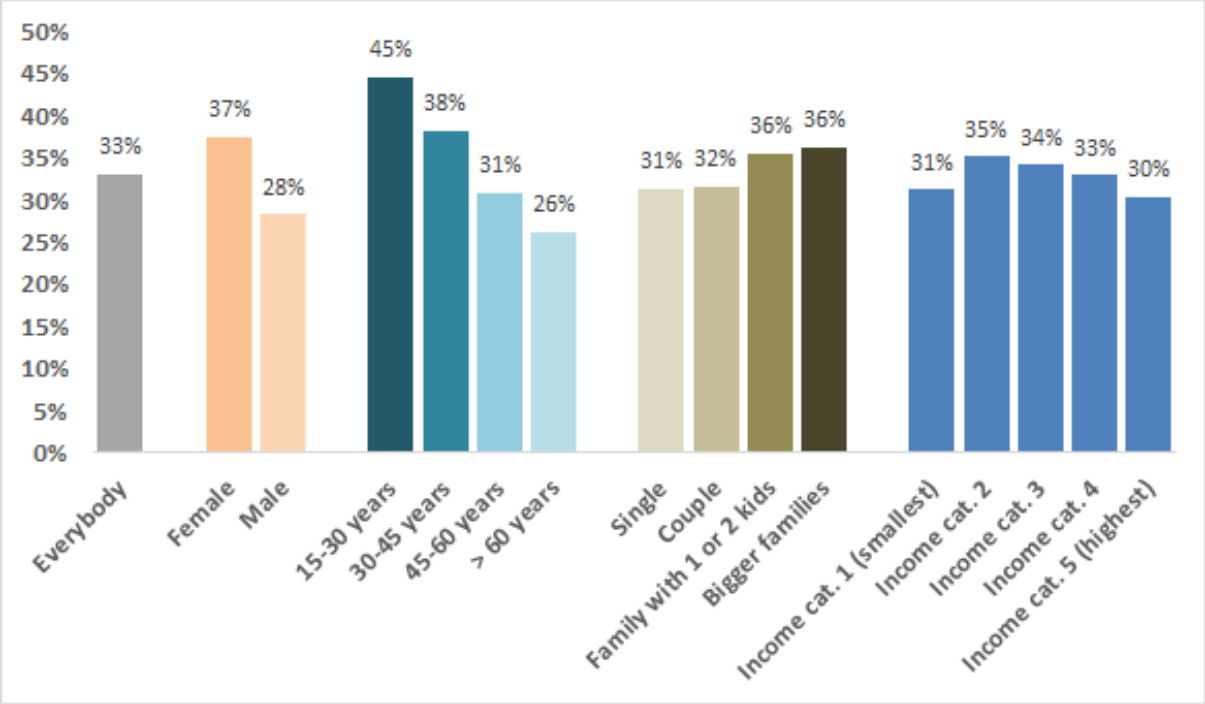

Figure 15: FULFILL survey (Task 3.1) – Share of people who "agree" or "strongly agree" to consider borrowing products from friends or acquaintances

In another survey in France, two more precise questions were asked about the readiness to share *'appliances and products'* (44% of positive answers), and share *'spaces, such as a communal laundry'* (26% of positive answers), here also with a similar correlation with age (ADEME, 2024). The European project Ps2SHARE found that willingness to take part in sharing platforms was highest among young, well-educated, and higher income Europeans (Andreotti et al., 2017).

Little specific literature on washing machine sharing has been found. A Swedish analysis looked at communal laundry use and prospects, and developed scenarios for Sweden and the EU to assess the potential of sharing (Wasserbaur et al., 2020). However, the trajectory building is highly normative and no sociological differences are considered.

On top of the socio-demographic considerations, there are also psychological and practical aspects that may influence sharing practices:

- Sharing may bring additional social interactions and a gain of space. However, using a shared washing machine is less immediate and practical than an owned machine. As women are still largely in charge of laundry chores, gender aspects are essential.
- Having one's laundry washed by someone else or left to dry in a common space challenges intimacy and property norms.
- Peer-to-peer sharing is most likely to take place in apartment buildings and dense urban areas. Communal sharing requires the presence or possibility of a shared laundry room in the building or vicinity. This is particularly common in co-living projects, where shared laundry is a typical feature (Huber, 2022). Laundromat use may only happen where a laundromat is available close by.
- A shared machine needs to remain fairly accessible and thus cannot be realistically shared by more than 7 to 8 households, because of typical usage patterns and the duration of washing cycles.

Based on these insights, age and gender appear to play a strong role in the inclination to take part in sharing practices. As the decision to own or share an appliance is probably not an individual but a household decision though, it seems difficult to isolate the gender variable in the

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practical decision to purchase a machine and/or share it with others (except for singles and same-sex couples). Due to this methodological complexity, the gender variable was unfortunately left aside and only the age variable is retained. In order to stick to available Eurostat statistics, the population of each country is split into three household groups according to the age of the adult(s) within the household:

- **Young households** (with adults from 18 to 24 years), most inclined to share
- **Average households** (with adults from 25 to 54 years and potential children)
- **Older households** (with adults above 54 years), least motivated to share but increasingly living in collective / nursing housing as they age (where laundry is washed collectively)

The dwelling location (whether it is in a multi-flat building that may host a laundry room or not, in a dense urban area, close to a laundromat, etc.) plays a key role too, and could also have been retained to distinguish population subgroups. However, there are significant data and methodological issues to do so (as the actual and future location of laundry room-ready buildings and laundromats is difficult to map). This variable is rather taken implicitly into account in the guidance target and trajectory design.

Guidance target

At present, about a third of the population in the covered countries seems inclined to consider sharing products (although they had potentially not laundry in mind when answering the surveys). This portion could grow as sharing becomes more mainstream and organised, especially in communal rooms. However, about half of EU households live in detached or semi-detached houses for which sharing will probably remain uneasy.

Besides, the aforementioned psychological and accessibility barriers justify caution and the 33% proportion already constitutes a challenging target and is judged to represent a ceiling (except in Denmark where communal sharing is more engrained in tradition). As a comparison, in their "*sharing*" scenario, Wasserbaur et al. (2020) hypothetically assume that half of the machine owners living in multi-family buildings shift to sharing at the end of life of their appliance. This leads to 75% of sharers in this type of buildings by 2050, meaning about 36% of the total Swedish population and 32% of the whole EU population.

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Barriers and enablers crossed with possible policies

The three types of sharing practices differ in terms of enablers, barriers, and potential policies (see Table 12).

Table 12: Barriers, enablers and potential policies identified for the three types of sharing practices

Sharing type	Barriers	Potential enablers	Relevant policies
Peer-to-peer	Access to peers	Digital tools	Support to sharing apps & platforms
	Workload & resource use for the sharer	Monetarised scheme	Facilitate remuneration schemes between peers
	Psychological reluctance	Information, success stories, etc.	Communication campaigns and legal framing
	Accelerated wear	More robust and repairable machines	EU regulations to increase durability & robustness
Communal laundry	Absence of a laundry room	Cohousing & space sharing projects are likely to increase the likelihood of communal laundry	*See the other related assumptions in sections 2.2 & 2.3*
	Unavailable space to install a laundry room	Installation works in existing buildings, laundry room by default in new buildings	EU legislation enforcing availability in new buildings & deep renovations (e.g. EPBD) Subsidies and legal framing to facilitate installation in buildings and neighbourhoods
	Maintenance requirements	Maintenance services in support of building owners	Reduced taxation on communal laundry services
Laundromat	Accessibility	Development of laundromat services	Adding laundry to public service facilities

No cultural or national variations are considered with respect to these barriers and policies, although this could be an area worth investigating. Nonetheless, the specificity of Denmark, (where communal rooms are much more common than in the other countries) has been taken into account to some extent in the trajectory design.

Most of these policies could be implemented relatively swiftly, except for the obligation to plan laundry rooms in new buildings & deep renovations, which would realistically require about a decade before being agreed, adopted, and producing effects.

In addition, any trend or policy that would increase the price of washing machines (e.g. constraints on manufacturing resources, performance regulations, etc.) could influence sharing practices.

Trajectory for each group: quantification rationale and narrative

The trajectories from the starting point till 2050 for the three household groups and sharing practices are built based on the following assumed dynamics:

- **Young households**: as the most eager to share and usually living in small flats, they see benefits in sharing and are the swiftest and most intense to embrace peer-to-

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peer sharing (which reaches 30% of the group population by 2050); they are also users of communal rooms when those start to become more generalised by 2040 (with 20% to 30% of these households using a laundry room by 2050, depending on the country).

- **Average households**: consisting in large part of families with children, these households live more in detached houses, have intensive laundry practices, and are less interested in the benefits of sharing; peer-to-peer develops more slowly within this group (and reaches 18% by 2050); the use of communal laundry rooms in apartment buildings and cohousing projects eventually becomes more normalised in the last decade to amount to 25% of this group in Denmark and around 15% in the four other countries.
- **Older households**: this population group remains reluctant to peer-to-peer sharing, which develops marginally (reaching only 7% by 2050); yet, as this ageing population group increasingly lives in shared housing facilities (according to the scenario assumption 2.3), communal laundry and laundry services grow in the group to reach around 20% of washing practices in the five countries.

The pace of change follows a rather flat curve in the first decade to account for the time required for sharing practices to become more mainstream in social norms. It also integrates the anticipated lengthy period necessary for communal laundry rooms to be enforced through legislation in new buildings and renovations. As regards laundromat users, considering the lack of data on this usage and on industry prospects, their share has been left constant until 2050.

The resulting trajectories for the three household groups are then aggregated to generate the trend on the total population. This step necessitates to model for each country the evolution of the size and share of the three groups within the national population until 2050. This is done through combining Eurostat general population projections by age, and statistics on how people are distributed between singles, couples, and others. The main retained assumption for the scenario is that population ageing follows the baseline Eurostat projection[17], while the structure of households [18] remains stable over time. A few approximations and extrapolations are necessary to estimate the resulting number of households corresponding to each age groups, adding a degree of uncertainty. A better job than this basic method would probably be possible with more refined household models and statistics.

In the end, the five national aggregated trajectories deliver the trends for the three sharing practices in each country. In order to translate these results into the evolution of the main chosen indicator, i.e. the ownership rate, a last assumption is necessary on the number of machines owned by the group of peer-to-peer sharers. It is supposed that within these households one machine owned is shared by 2 households from the beginning till 2030, and then this rate increases to 3 households by 2040 to reflect an intensification of the practice as it becomes more organised and normalised. As regards laundromat and communal laundry machines, they are excluded from the calculation as they are not counted in residential ownership rates.

Results

The final calculation leads to the following trajectories for washing machine ownership rates in the five countries (Figure 16).

[17] https://doi.org/10.2908/PROJ_19NP
[18] https://doi.org/10.2908/LFST_HHINDWS

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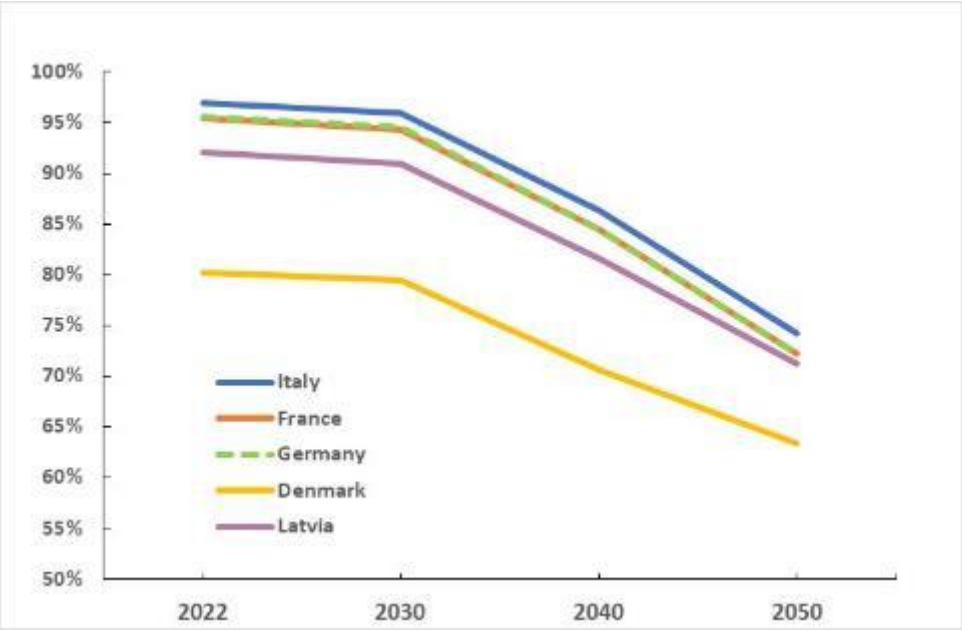

Figure 16: Residential ownership rate trajectories by 10-year steps

Denmark has specific starting and end points reflecting the existence of communal laundries in the country. The four other countries end up in 2050 at a similar ownership rate still above 70%. This means that the possession of washing machines remains largely dominant, although the sharing dynamic starts producing substantial effects after 2030. Peer-to-peer sharing is practised by only around 13% of the population in 2050 and is notably hampered by population ageing, while communal sharing in laundry rooms rises to 25% in Denmark and between 15 and 20% in the four other countries.

This decrease in ownership rates means that the installed stock of machines is smaller than at the starting point. The trajectory over the five countries translates into a 20% smaller stock in 2050 (counting residential and communal machines altogether). This reduction may mean less manufacturing of washing machines and less resource and energy used for production, provided the shared machines do not fail earlier and can withstand more frequent cycles over the same lifetime. This requires effective durability and repairability regulations. Supposedly, machines installed in communal laundry rooms will be tailored to intensive use and may be better maintained by laundry services compared to residential ones.

The environmental impact of washing machines also stems from washing cycles. Are usage patterns of sharers similar to that of non-sharers? In the absence of solid evidence, it is difficult to answer, yet it seems reasonable to assume in line with Wasserbaur et al. (2020) that due to more constraining conditions sharers wash less frequently and better load the machine. A 25% reduction in annual cycles is supposed (compared to 30% in Wasserbaur et al., 2020). This generates potential savings on electricity, water and detergents, that are assessed in FULFILL (2024).

Discussion on the assumption

This modelling approach goes further in terms of socio-demographic aspects than other appliance sharing models such as Wasserbaur et al. (2020). However, only the washing machine case could be modelled and other products would be promising candidates (e.g. cars, clothes, tools, etc.).

The subdivision of the population into three household age groups remains relatively basic, as it does not account for couples with large age differences, recomposed families, atypical households, etc.

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As already said, promoting new practices that may induce additional constraints and efforts on laundry chores needs to be carefully analysed through the gender lens. None of the suggested policies would force anyone to share, yet psychological pressure could exist within couples.

The modelling has not covered potential rebound effects. There is a risk that by providing easier access not only to washing machines but also tumble driers, sharing practices trigger an increased use of driers compared to today. Dry clothes are easier to carry around, so the risk is real.

Peer-to-peer sharing is the most uncertain practice as there is insufficient research and evidence to guarantee that the barriers could be overcome (at least for a fraction of the population), in the absence of hard legislation. Communal laundry rooms and services are more promising (and this is reflected in the trajectory building), however, the implementation and development require time and urgent policy decisions to ensure new apartment buildings and major renovations include this requirement early enough.

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2.5. Moderate car sizing

Table 13: Summary of the construction of the quantified trajectory for the "Moderate car sizing" scenario assumption

Perimeter of study	Make smaller car segments dominant in sales.
Indicators	Shares of new passenger car sales by segment.
Past trends	Increasing share of SUVs to the detriment of smaller cars.
Population groups	Household size considered in prospective, and entities.
Guidance target	None.
Policies	Regulation, fiscal schemes and incentives targeting manufacturers, entities and individuals. Mid/short-term for entities, mid/long term for individuals.
Main elements underlying the quantified trajectory	Target-based approach on assumed need according to household size. Individuals and entities have the same target, but different paces: target reached in 2035 for entities, 2045 for individuals.
Main results	Evolution 2019 - 2050 of sales of new passenger cars by segment. By 2045, SUVs represent on average 5% of new car sales, while micro cars represent on average 16%.
Discussion	Lack of consideration of economic aspects, policies not directly modelled, little differentiation between countries, uncertainties on the emergence of microcars and their usage.

Perimeter of study and relevant indicators

Car sizing illustrates the necessity to associate sufficiency policies to energy efficiency regulations. The "*SUV problem*", analysed by the public think tank France Stratégie in 2019, shows how energy efficiency gains achieved in the last fifteen years through Euro norms were progressively outbalanced by the evolution of production (and consumption) towards larger, heavier, and higher cars from 2016 on (Meilhan, 2019). With a revised CO_2 emission on cars regulation aiming to reach a 100% electric fleet (EU Regulation 2023/851,2023), the issue of car sizing remains important but still lacks consideration at the policy level. Multiple challenges are at play:

- Raw material criticality (risk of shortage at the international level for lithium/nickel material in the context of exponential market development and necessity to limit the size of electric vehicles (EV) batteries to limit raw material consumption) (négaWatt Association, 2023).
- Externalities associated with large cars (SUV) regarding accidentology (Fehr, 2020), particles pollution (ANSES, 2019), degradation of road infrastructures, higher energy consumption (Meilhan, 2019) and less road space for active modes (T&E, 2024).
- Higher costs of big vehicles, questioning the access to all to less polluting vehicles.

In this sufficiency scenario assumption, we aim for making smaller car segments dominant in sales with the implementation of relevant policies and measures. We only look at passenger cars, i.e. light duty vehicles are out of scope. For segment categories, we refer to the European Commission classification, i.e. categories from A to J (European Commission, 1999), and we introduce a segment: microcars[19]. Reducing weight by segment is out of scope.

[19] We define microcars as cars that weigh 500 kilograms or less. A typical example is the Renault Twizy.

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We consider households and entities owning at least one car and we use the shares of new passenger cars by segment as the sufficiency indicator.

Macro data analysis, past and present trends

Data for car sales comes from Statista. As shown in Figure 17, in the last decade, SUVs have taken a larger share at the expense of small and medium cars mostly (Statista, 2023).

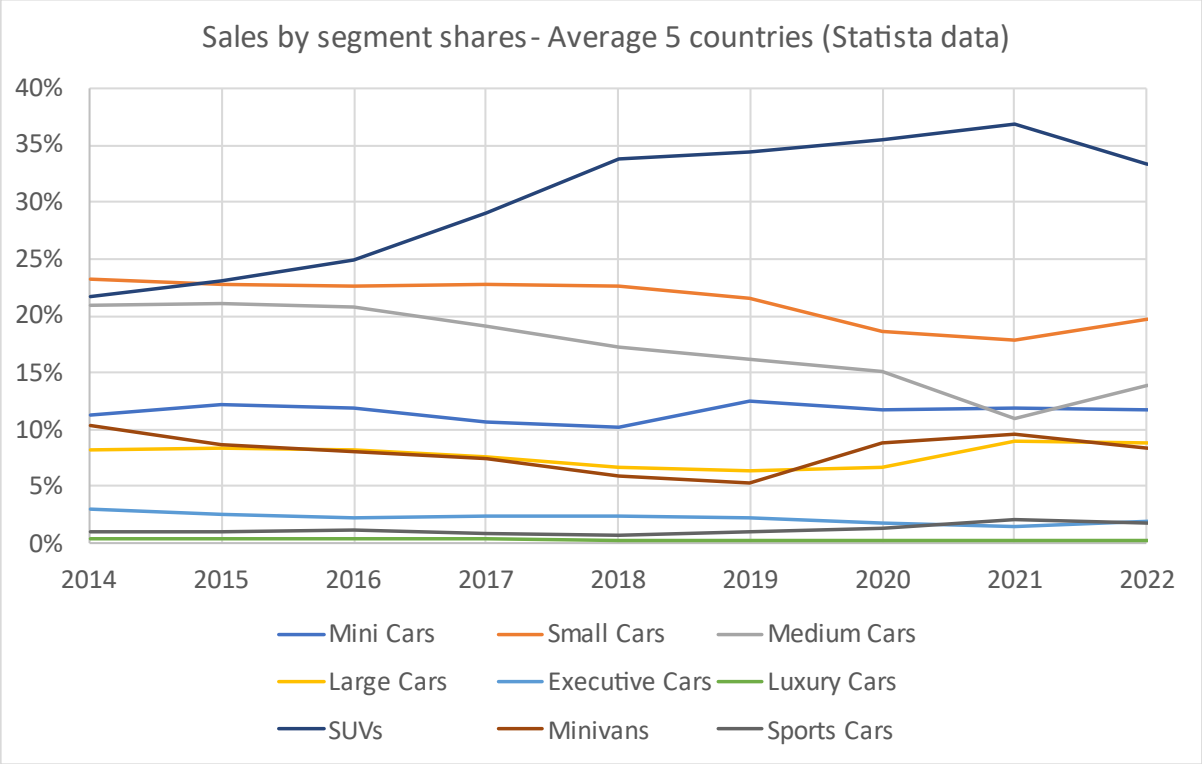

Figure 17: Shares of new passenger car sales by segment, 5 countries-average

This evolution is following a global trend [20] and is at least partly due to a strategy of manufacturers consisting of promoting larger cars because they are more profitable (Munoz, 2021).

Insights from SSH and main socio-demographic variables retained to form population groups

Contrary to other sufficiency assumptions where we define social groups of individuals, we rather distinguish here between entities[21] and individuals. Indeed, if we look at the distribution of sales, we observe that entities make up the largest share, at least in France and Germany, where they account for more than 50% of new vehicles sold, and this share has been growing (CGDD, 2019; KBA, 2021). In addition, they mostly buy new vehicles instead of second-hand ones and renew their fleet faster than individuals (at least in France: CGDD, 2019), so they likely shape the second-hand market in a major way. In particular, leasing companies have been identified as a potential key driver of affordable electric cars in the EU (T&E, 2023). Company

[20] https://www.iea.org/data-and-statistics/charts/new-registrations-of-suvs-in-key-car-markets-2010-2021

[21] Entities include distributors (demo vehicles), manufacturers, businesses, administrations, rental and leasing companies.

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cars that are left to the employees for work as well as for private driving may also be an influence of entities on the car stock, although we did not find robust data on this aspect.

Regarding individuals, there are several factors that were examined related to car size: perceived need, age, household size, and income. These were chosen according to available surveys and are not exhaustive. A cross-sectoral survey on sufficiency in France indicates that 78% of respondents consider that possessing a large car is dispensable (ADEME, 2024). This figure is disaggregated by age: it appears that around 30% of people between 25 and 44 years old consider a large car is necessary, against about 15% of people between 18 and 24 years old and about the same share of people between 55 and 75 years old.

To try to understand this discrepancy, we looked at FULFILL survey data, namely the type of vehicle used the most by respondents according to their age and life stage (see Figure 18).

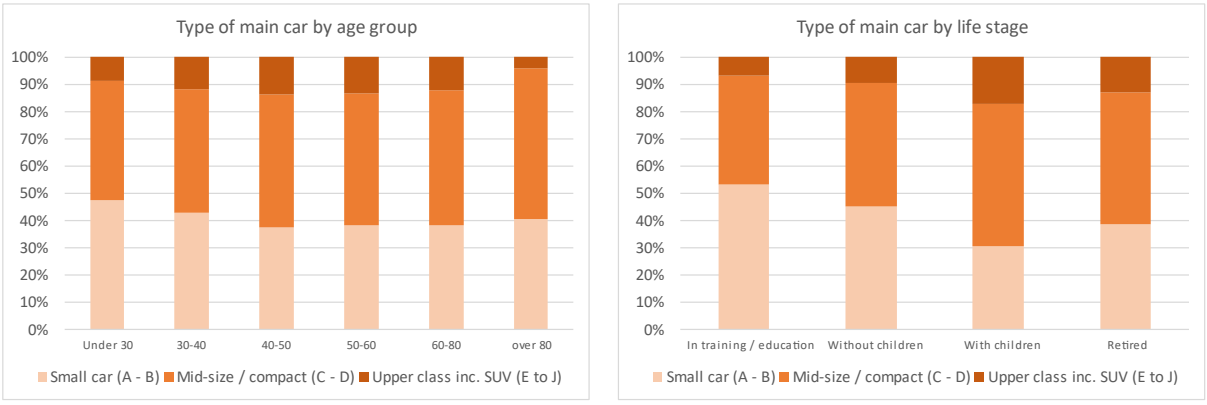

Figure 18: Type of main car used by age group (left) and life stage (right), for the 5 FULFILL countries aggregated (FULFILL survey)

This data is only partially consistent with the previous survey. It seems that life stage, especially parenthood, explains differences better than age. This seems logical and is confirmed when we look at household size, although larger households do not always correspond to a couple with children (see Figure 19):

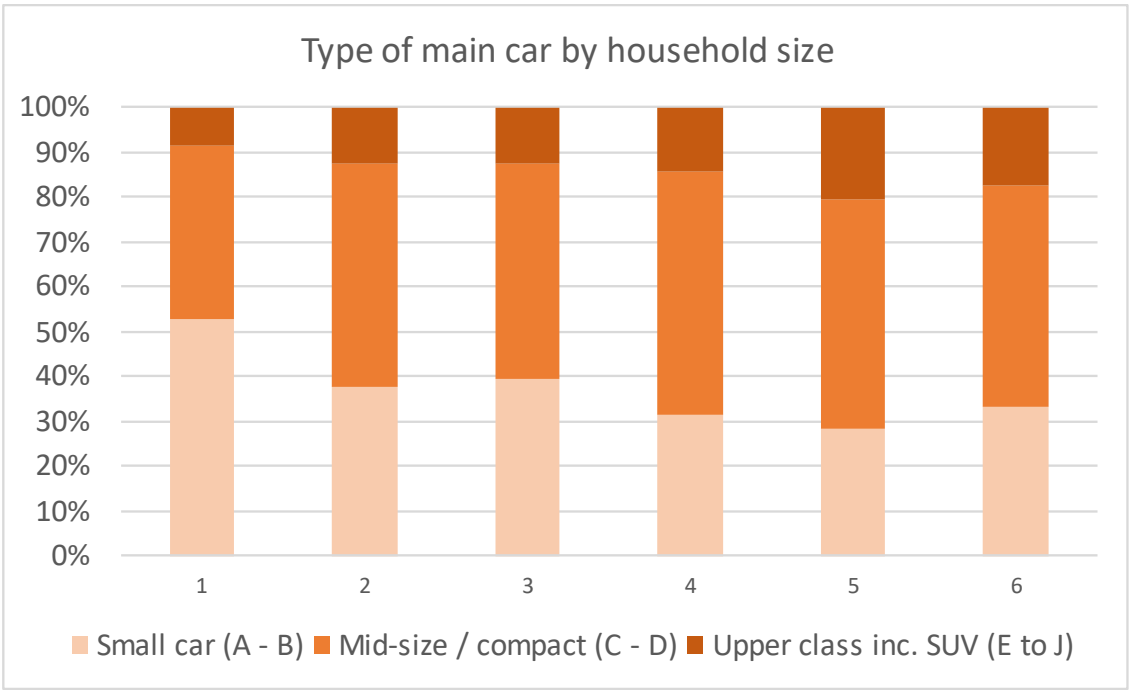

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Figure 19: Type of main car used by household size, for the 5 FULFILL countries aggregated (FULFILL survey)

As this data concerns cars used by the household most of the time and not purchased, we cannot use it directly in our trajectory, since we use the new car sales indicator instead. Besides, people mostly buy on the second-hand market (Husson, 2014; T&E, 2023), suggesting that only a minor part of the population buys new cars.

As such, income certainly plays a role, and this has been confirmed by surveys (Demoli, 2015; FULFILL, 2023c, see Figure 20). But this variable was not considered because of our modelling limitation with regard to macro-economic variables and changes.

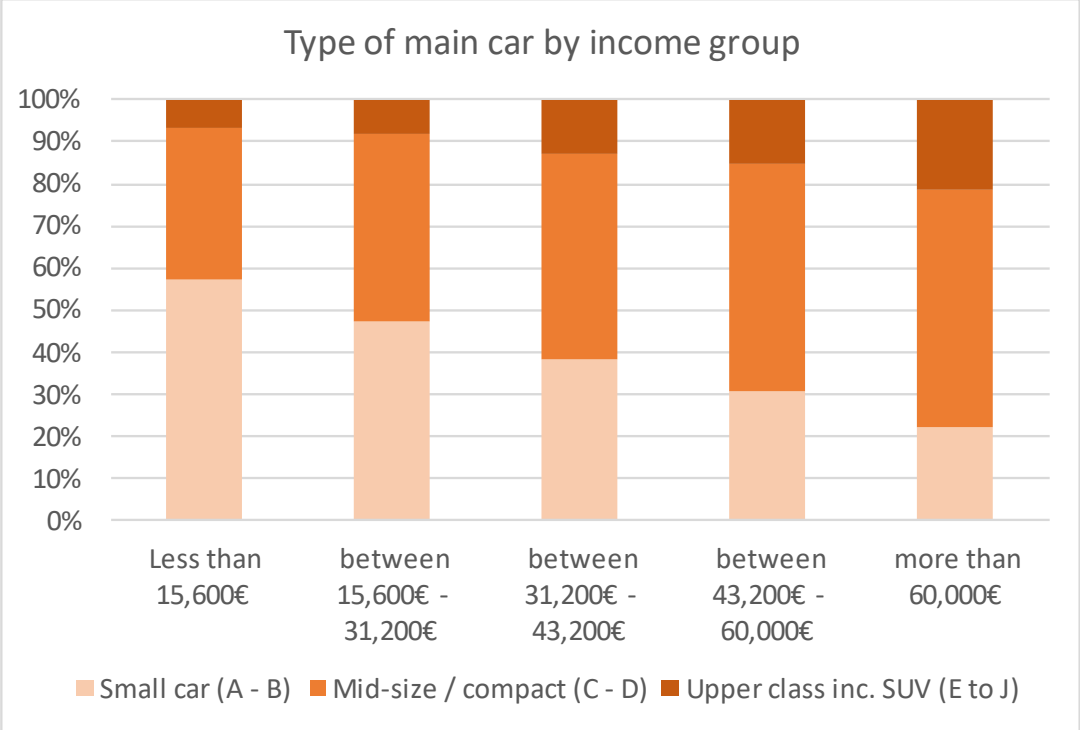

Figure 20: Type of main car used by income group, for the 5 FULFILL countries combined

Overall, we retain household size as a relevant variable to model prospective sales. However, we lack data to disaggregate sales by household size. To get around this problem, we build a trajectory on the average shares of new car sales by segment but calculate the target according to an assumed need disaggregated by household size; i.e. we use this disaggregation in prospective even though it is not available in historical data (see section Trajectory below).

Barriers and enablers crossed with possible policies

The European car market overview showed that the new vehicle market has a key role in defining production patterns for manufacturers, as well as consumption patterns for end-consumers on the secondary market (Munoz, 2021; T&E, 2023). Also, as said previously, companies represent a major share of the new vehicle market and are thus a key target for car sizing policies. Their consumption patterns define the type of vehicles circulating on both the new and secondary car market. On the other side, individual consumers represent less than half of the new car market, and show a homogenous profile of mostly rich, aged[22] households (Demoli, 2015). These figures underline the need for policy attention on the economic accessibility of EV.

Analysing existing schemes

[22] To be distinguished from the previous discussion on age, which regarded the main vehicle owned. Here, we refer to the new car market.

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Policy schemes related to the scenario assumption were analysed in EU and non-EU countries, the note is present in annex.

In most countries, fiscal incentives favour EV but do not take the weight and size into account, except recently for Norway. A large number of European countries have a CO_2 component in their car tax system, albeit to varying degrees.

We observe that in most EU countries where the car industry plays an important role (Spain, Germany, Italy), there is no weight penalty. France is an exception, but it should be remembered that the weight component of the penalty means that the majority of French manufacturers' models are still spared, while Chinese and German manufacturers are targeted. What's more, taken as a whole, the penalty has historically been too low to curb the rise of the SUV.

European regulations encourage manufacturers and decision-makers to focus on the issues linked to vehicle CO_2 emissions, to the detriment of other criteria. In 2019, a new regulation was introduced by Regulation (EU) 2019/631[23], which sets *"a Union-wide target of 95 g CO_2/km for the average emissions from new passenger cars registered in the Union and a Union-wide target of 147 g CO_2/km for the average emissions from new light commercial vehicles"*.

Policy narrative

Working on the policy narrative on car sizing revealed interconnexions with environmental, health, social and industrial variables, underlining the need to integrate car sizing policies within a global mobility strategy. First, national health organisations call for road traffic reduction policies in addition to decarbonisation measures to reduce both climate and health negative externalities of road transport (ANSES, 2019). Secondly, environmental, and social priorities should be further balanced. An analysis of existing obligation or fiscal schemes in European countries (see note in annex) shows a focus on daily transport, in which both geographical and income-based inequalities are apparent between those having access to infrastructure (collective or soft transport modes, service facilities), and those needing to drive daily, when long-distance transport remains mostly out of the scope of national and local policy regulation (Reichert et al., 2016). Thirdly, car sizing policies feed into a larger debate on the evolution of public funding supporting transport policies. Largely focused on CO_2 emissions in all EU member States, the transition to a 100% EV fleet calls for an evolution of fiscal tools towards material, health and infrastructure externalities (Conseil des prélèvements obligatoires, 2019).

Investigating different narratives and policy approaches also allowed us to consider the multiplier effect between different policy tools at the local, national, and EU level. If consumers receive signals and incentives at all levels to use smaller cars, the impact will be increased.

The comparative analysis of existing policy schemes in several EU and non-EU states (see note in annex) allowed us to identify a list of enablers and barriers at play for each policy action, either normative, social, economic, environmental, geopolitical or narrative (see Table 37).

- On the normative side, we looked at whether similar norms or regulations already exist, assuming that it would be easier to support them in the political agenda if they do. We also looked into methodological challenges (complexity of the norm, e.g. market or fiscal tools based on a life cycle emission analysis). We also considered external variables such as normative constraints from free market rules. We evaluated the political influence of non-environmental narratives or policy priorities as a way to support car sizing restrictions, such as growing concern over raw material criticality (economic and geopolitical issues), urban planning constraints, space and traffic congestion generated by larger vehicles, infrastructure management, road safety and accidentology, industry relocation for the microcar segment. We investigated how car sizing fiscal schemes could be politically supported considering the necessity to change the financing base for transport policy in a 100% EV fleet horizon. We also looked at social and economic narratives associated to sufficiency and the implementation of a just transition: small cars are more

[23] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32019R0631

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affordable, and developing a microcar industry as well as limiting the size of cars offered on the market could allow for a fairer access to EV than today. Redistributive schemes were also investigated to tax big vehicles (mostly bought by companies or wealthy households) to fund a bonus on small vehicles, making them more affordable to middle- or low-income households (CCC, 2021). We also investigated local schemes, such as the fiscal project considered by the city of Paris on parking rates based on weight and size of vehicles (City of Paris, 2024). Barriers were also considered, allowing us to identify important variables at play: political influence of the car industry lobby (see note in annex). Societal narratives, actively conveyed by car advertisement: gender and social status (Demoli, 2015), the idea that bigger vehicles are safer, that families require big vehicles (Ali et al., 2018). Existing policy bias focusing on decarbonisation mainly and not sufficiency (fiscal schemes).

Regarding the pace of change, our policy analysis suggests, from the evaluation of expected full-impact horizons, that entities could reach the target by 2035, and individuals by 2045 (see Table 39). For reference, in Norway, sales switched almost completely in about ten years[24] thanks to incentives on electrification.

Associating the existing regulation for 2035 regarding the ban of thermal cars (EU Regulation 2023/851,2023) to regulations on weights and sizes would avoid lock-in effects that could lead to a lasting heavy vehicle stock of electric SUVs.

Trajectory for each group: quantification rationale and narrative

It would be complex to directly model the impact of proposed policies, as they are a mix of regulations, taxes and incentives. Moreover, we do not model income, whereas entities and households may react differently to taxes or incentives accordingly.

Instead, we derive target prospective shares from an assumed household need, according to their size – as discussed previously – and the number of cars they own. Respective distributions (shares of household sizes and number of shares of number of cars owned) are extracted from FULFILL survey data and considered constant, except for households with more cars than people for which we propose to reduce progressively the number of cars owned. Target shares are calculated following the rules below:

- No household buys more cars than its number of people.
- A share of households continues to buy cars deemed too large, based on the ADEME survey: 15% of households of one or two persons, and 30% of households of 3 persons or more buy *"large"* cars.
- At most, households buy one *"large"* car. Thus, households with several cars will only buy "*light*" cars in addition to their first.
- Households with only one car have a car large enough to transport all household members at once.
- What is deemed a *"large"* car depends on the household size: from segment C, D or M (medium cars, large cars or minivans. See Table 14).
- Shares of "*large*" and "*light*" cars are arbitrarily divided equally between segments, but it seems conservative as it does not disfavour large cars, contrary to what would be expected with suggested policies. Exception are executive, luxury and sports car shares, each set at 0.3%, which is the average historical share of luxury car sales: this value can be discussed but its impact on the results is marginal.
- This results in the following shares disaggregated by household size and number of cars (see Table 14):

[24] https://robbieandrew.github.io/EV/

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Table 14: Shares of "large" car in sales in 2050, per household size and number of cars owned per household

Household size	Number of cars owned per household	Share of large cars in sales	Threshold segment from above which cars are deemed too large
1	1	15%	C
2	1	15%	C
2	2	7.5%	C
3	1	30%	D
3	2	15%	D
3	3	10%	D
4	1	30%	D
4	2	15%	D
4	3	10%	D
4	4	7.5%	D
5	1	30%	D
5	2	15%	D
5	3	10%	D
5	4	7.5%	D
5	5	6%	D
>=6	1	100%	M
>=6	2	50%	M
>=6	3	33%	M
>=6	4	25%	M

We infer an average value of shares of new car sales which is the target for 2050. Differences between countries stem solely from differences in household size and car ownership distributions (see Table 15).

Table 15: Target shares in 2050 of new car sales by segment and by country

Target	Micro cars	Mini Cars	Small Cars	Medium Cars	Large Cars	Mini vans	SUVs	Executive Cars	Luxury Cars	Sports Cars
France	16%	26%	31%	13%	4%	5%	5%	0.3%	0.3%	0.3%
Denmark	17%	28%	31%	10%	4%	4%	4%	0.3%	0.3%	0.3%
Latvia	15%	25%	30%	13%	4%	5%	5%	0.3%	0.3%	0.3%
Germany	17%	28%	31%	10%	4%	4%	4%	0.3%	0.3%	0.3%
Italy	14%	23%	30%	16%	5%	5%	5%	0.3%	0.3%	0.3%

We assume that this targets also applies to entities: data regarding their purchases by segment was not available, so we assume that the shares of new cars are the same. As a result, entities and individuals are only differentiated by their respective pace. We assume that entities could reach the target by 2035, and individuals by 2045 (see section on barriers and enablers). 2025 is a market forecast from Statista. In the absence of more in-depth analyses on the possible impact of policies, the trajectory between 2025 and the target year is arbitrarily set as linear.

Lastly, the shares of sales for entities and individuals are set constant throughout the trajectory at respectively 52% and 48%, based on French data (CGDD, 2019).

Results

NB: 2019 was chosen as a starting point because 2020 may not be representative because of Covid-19.

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The trajectory shows a share of SUVs progressively getting marginal, even though, as described previously, some room has been left for large cars. At the same time, we observe the penetration of both micro and small cars. We note that 2035 is a bit of a pivotal year, corresponding to the target year for entities.

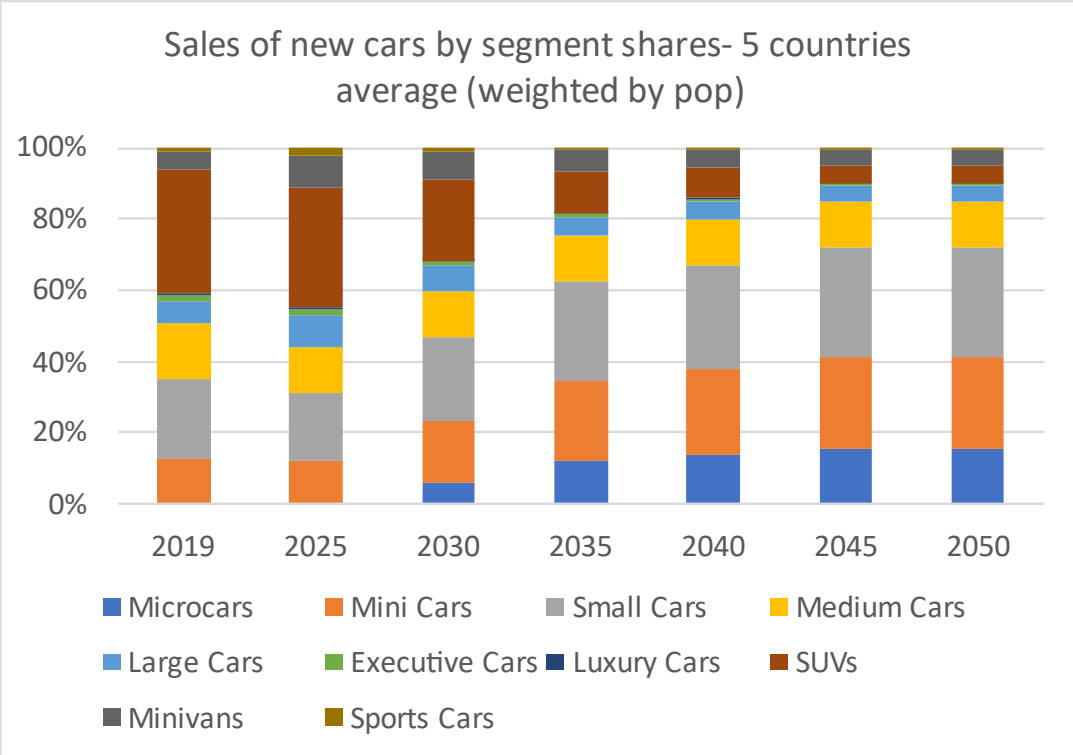

Figure 21: Evolution of the sales of new cars by segment shares, average for the 5 countries weighted by population

Discussion on the assumption

A possible improvement for this sufficiency scenario assumption would be to better understand the economic issues at play and take them into account when quantifying the impact of policies. For example, a sectoral expert with whom we exchanged mentioned that the selling price on the second-hand market is a determinant factor for leasing companies when determining their renting price. They have been observed to rent smaller cars at a higher price than SUVs because bigger cars are more profitable on the second-hand market. Bigger cars are also of greater economic interest to manufacturers: we did not investigate what a switch to smaller car segments would imply in terms of quantified revenue, jobs, etc. for the car industry and entities in general. Lastly, tax policies may not be as effective as expected, as car buyers – at least part of them – may not be highly sensitive to them. The level of disincentives for both large and small cars need to be more thoroughly investigated to ensure fairness, for example by studying the elasticity of buyers to prices and taxes. Also the economic issue of EU reindustrialisation in the context of the global competition regarding the EV industry is an important aspect that should be investigated further.

As said previously, there is not much differentiation in terms of target between countries. We assume policies to be applied uniformly across the 5 countries, progressively attenuating cultural differences. We did not see reasons to keep these differences and it does not seem equitable to assume that a country could keep a higher consumption of SUVs than the others.

Lastly, it could be interesting to deepen the discussion on microcars in order to depict more precisely their context of use and their practicality in everyday life situations. We note that the share of microcar sales obtained is 7 percentage points lower than that of the French négaWatt

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scenario (négaWatt association, 2022), so it seems possible to build a more ambitious trajectory for this segment.

2.6. Biking

Table 16: Summary of the construction of the quantified trajectory for the "Biking" scenario assumption

Perimeter of study	Modal shift to biking in daily mobility
Indicators	Share of trips and share of distances covered by bike in daily mobility
Past trends	High level of modal shift long ago in some countries, some progress more recently in countries where it remained lower
Population groups	No specific group, the evolution concerns the whole population, taking into account physical ability
Guidance target	Level of modal shift achieved in the most advanced areas
Policies	Based on return of experience in most advanced places, they include the development of numerous, safe and convenient infrastructures, incentives, information, and the local improvement of bikeability, with impacts on usages in the short term and more structural ones in the longer term
Main elements underlying the quantified trajectory	Some limitations (national and local population and road density) modulate the share of modal shift that can be achieved, compared to the maximum target
Main results	The modal share of biking in daily and regular mobility is projected to reach a range of 22.5% to 30% of all trips, and 7.5% to 10% of the distances covered
Discussion	The projection of modal share would need to consider the entanglement with changes in other modes and travel needs, to discuss how past policies can be as effective in today's context, and to consider the role of emerging options (e-bikes, e-scooters…) to reshape alternatives around more hybrid approaches

Perimeter of study and relevant indicators

Modal shift to biking is a well identified sufficiency lever to reduce the use of cars, particularly in the case of daily mobility, where it can more easily substitute the car. It has long been acknowledged to be a significant lever in sufficiency-based strategies applied to decarbonise transport, whether it is through the sufficiency-efficiency-renewables (SER) framework, or the introduction of the avoid-shift-improve (ASI) concept (Dalkmann et Brannigan, 2007). Moreover, it is a change that has strong and direct connections to lifestyles, as it affects individual choices regarding the way we travel and the time we spend on daily trips. However, it also has significant consequences on urban planning, city and town landscape, etc.

Shifting to biking can apply to many of our trips, covering different purposes, and to a large part of the population. The chosen perimeter covers therefore all trips that contribute to daily and urban mobility. In European statistics, daily short-distance mobility accounts for all trips of less than 300 km, while the part of it that is defined as urban trips accounts for all trips of less than

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100 km in the same urban area (Eurostat, 2021)[25]. As such, between 2017 and 2019, daily urban mobility roughly accounted for 55% (Denmark) to 81% (Italy) of trips in daily mobility, and 34% (Denmark) to 53% (Germany) of distances[26].

The perimeter therefore includes the shift to biking in daily urban trips that encompass purposes of commuting to work, business and professional occupation, education, shopping, leisure, personal business, therefore excluding practices related to sportive cycling or long-distance tourism by bike.

The sufficiency indicator chosen is the increase in the modal share of bike trips, which is two-fold: it is measured both in terms of number of trips (the share of trips by bike in urban daily mobility, as compared to the total number of trips), and in terms of distances (the share of the distance covered by bike compared to the total distance covered).

Macro data analysis, past and present trends

The share of biking in distances covered for daily urban mobility is relatively low, as cars are still dominating mobility uses. According to surveys in 2019 in France (SDES, 2019) [27] and between 2017 and 2019 in the four other countries (Eurostat, 2021), car trips (as a driver, passenger, in a taxi, or in other vehicles such as vans) accounted for 68% to 83% of distances covered for this local or daily urban mobility, while cycling accounted for 1% in France or 2.2% in Latvia to 7.5% in Denmark, as shown in Figure 22. Although this share might seem small in all countries, there are nevertheless significant differences. The average daily distance covered per person for urban mobility ranges from 10.2 km in Latvia, 11.4 km in Italy, to 16.5 km in Denmark and 19 km in Germany. In comparison, on average (across the 5 countries studied in FULFILL) people cycle less than 80 km per year in Latvia for daily urban mobility, but more than 380 km on average in Germany, and more than 450 km in Denmark, i.e. 3.8 to 4.7 times more.

[25] More precisely, urban mobility is defined as "*trips made by residents of an urban area, where both origin and destination are inside the same urban area*". All trips made within a Functional Urban Area (FUA) by the entire population living inside and outside a city should therefore be taken into account, but for these results, "*urban mobility is restricted to trips shorter than 100 km*". Short-distance mobility is defined as any trip of less than 300 km. Unlike urban mobility, there is no restriction about the type of origin and destination areas.

[26] These Eurostat data from 2021 are based on surveys that were conducted respectively in 2017 for Germany and Latvia and 2019 for Denmark and Italy, while France was not covered.

[27] Although comparable to European statistics in its approach, the survey for France uses a more restrictive criterion, defining its perimeter as that of *local mobility*, which encompasses all trips within a bird's-eye distance of 80 km from home.

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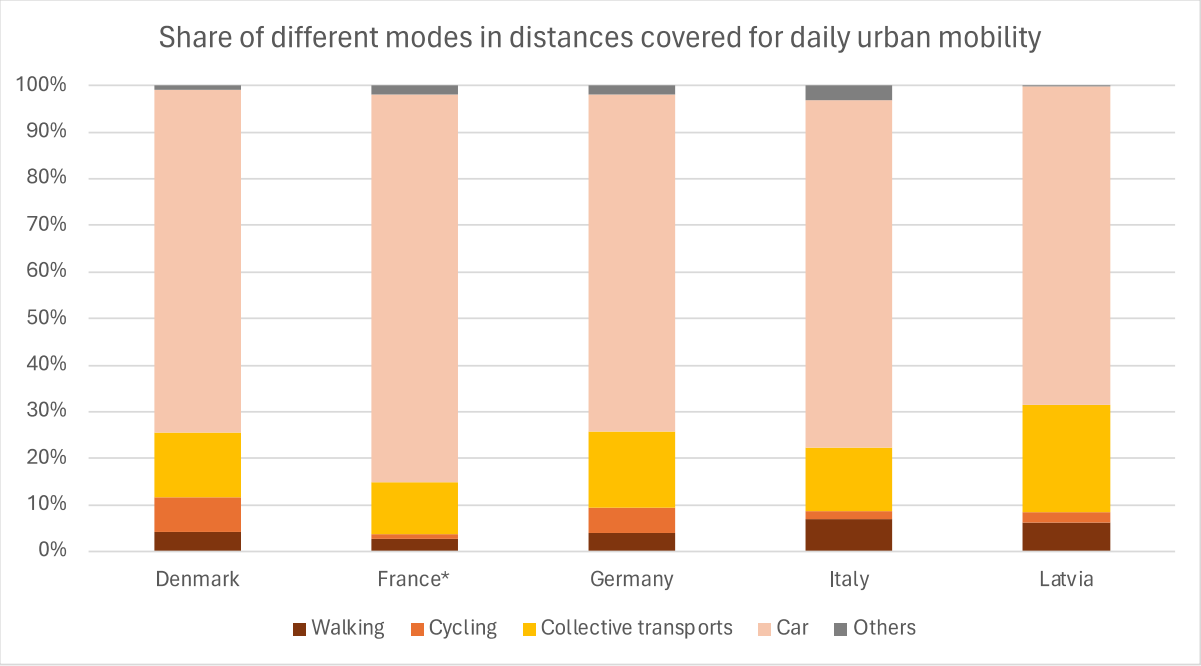

* For France, this is the share of local mobility (trips within 80 km of home); for the other countries, this is the share of daily urban mobility (trips of less than 100 km within the same urban area).

Figure 22: Share of cars, cycling and other modes in daily urban or local mobility (share of distances covered) in the 5 countries (Eurostat, 2021; SDES, 2019)

These surveys do not provide detailed data on the relationship between the mode and the purpose of trips. As shown in Figure 23, it is interesting to note, however, that the share of purposes in total covered distances is broadly similar in all countries, with professional and educational purposes amounting to 40% to 50% of distances (although differences in detail might relate to differences in the detail of categories used in the national surveys). In other words, commuting trips, which are expected to have the most important framing role regarding the choice of the main mode for daily mobility, carry a similar weight and do not appear to be a possible explanation to differences in the distances covered by bike.

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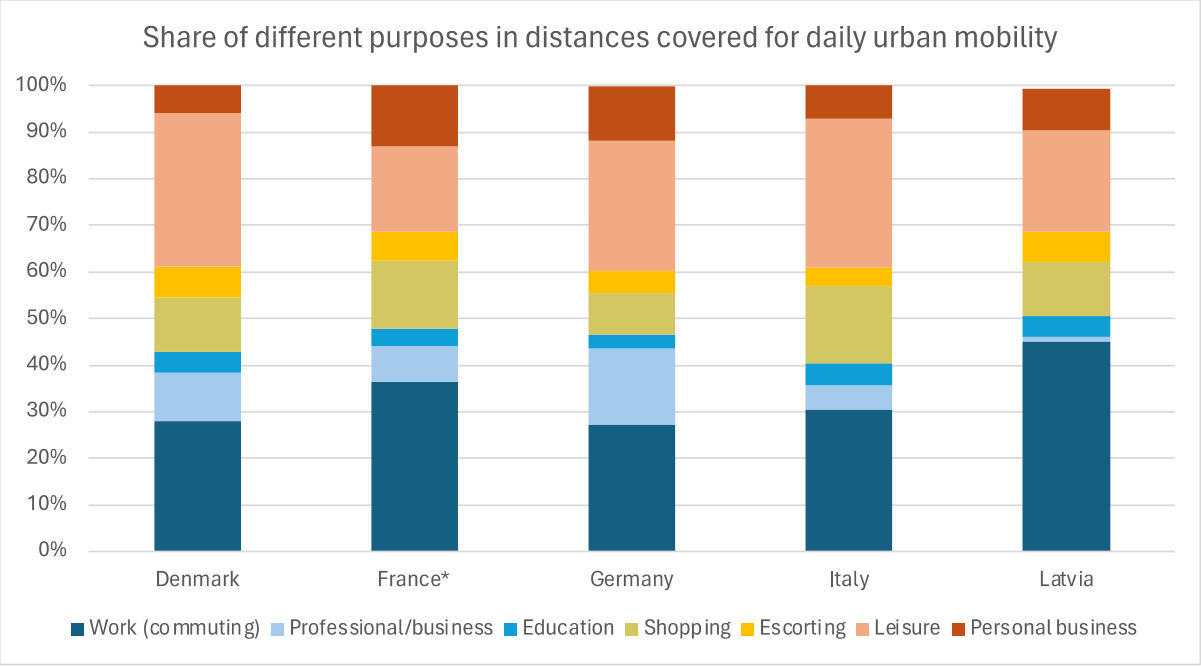

* For France, this is the share of local mobility (trips within 80 km of home); for the other countries, this is the share of daily urban mobility (trips of less than 100 km within the same urban area).

Figure 23: Share of purposes in daily urban or local mobility (share of distances covered) in the 5 countries (Eurostat, 2021; SDES, 2019)

As such data are most often derived from large-scale declarative surveys, which are rarely conducted and may differ from country to country and year to year, it is difficult to examine past trends on a global basis. They nevertheless appear to vary greatly between the five countries. In France, for instance, previous studies show that the share of biking trips in local mobility (as a percentage of the number of trips, regardless of the distance) decreased from 4.5% in 1982 to 2.9% in 1994, 2.7% in 2008 (CGDD, 2010), and then 2.6% in 2019 (SDES). In Denmark, where the share of biking is much higher, the number of daily km cycled by the population seems to have peaked in 2017, with 8.7 million km cycled daily on average; in 2021, it returned to the same level as in 2010, with 6.6 million km, but rose again to 7.7 million km in 2022 – as reported by the National cycle account (NVC, 2023). This might illustrate a post-Covid effect. In France, where this situation boosted more proactive policies to support biking, it is estimated that a 28% increase in its practice occurred in 2021. In the country where biking is the most advanced in Europe, the Netherlands, the share of journeys by bicycle has been very stable from 2012 to 2019, at about 27-28%, then fell to 25% by 2021, before returning to 28% in 2022 (De Haas et Kolkowski, 2023).

Insights from SSH and main socio-demographic variables retained to form population groups

Socio-economic and demographic factors are known to play a role in the use of bike. A large European-wide survey revealed that in 2020, amongst all respondents with daily or regular mobility (almost 27,000 persons), significant differences appear in the number of people who use bike as the main mode or as part of a combination of modes, depending on the category (European Commission, 2020). Some details are provided in Table 17. In particular, while gender-related or age-related differences seem limited, more important ones can appear with the level of education, the socio-professional category or the level of income: on average, students use bikes 1.5 times more than the average, and twice more than homemakers or those whose education ended at 15 or before; people who do not have difficulties paying bills are twice more likely to use bike in their daily mobility than people who regularly have difficulties paying them. Place of residence also plays an important role: people who say they live in large towns

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use bikes and scooters less than those who say they live in rural areas, and even less than those who say they live in small or mid-size towns.

Table 17: Percentage of people with daily or regular mobility for whom biking or scooting are the main mode of transport or are combined with their main mode of transport, according to different socio-demographic variables (Eurobarometer survey, 2020)

		Gender		Age				Urbanisation (subjective)		
Main / combined mode of transport	**Average EU28**	Man	Woman	15-24	25-39	40-54	55+	Rural village	Small / mid size town	Large town
Privately owned bike or scooter*	**14**	15	13	17	13	13	14	14	16	11
Urban shared bike, scooter or moped*	**3**	4	2	5	3	3	3	3	3	3

	Education (end of)				Socio-professional category								Difficulty paying bills		
Main / combined mode of transport	15 or before	16-19	20 or later	Still studying	Self-employed	Managers	Other white collars	Manual workers	House persons	Unemployed	Retired	Students	Most of the time	From time to time	Almost never / never
Privately owned bike or scooter*	10	12	17	20	11	18	12	12	10	13	14	20	8	10	16
Urban shared bike, scooter or moped*	3	3	3	5	3	3	2	4	2	3	3	5	3	3	3

* Including electric ones

Beyond such aggregated results on the European level, socio-economic and demographic factors can also be observed at country or more local level. They generally show the same level of differences between categories, although the dominant factors can depend on different contexts. In France, where biking seems to be less advanced than the European average, the education level plays a similar role, with people with a two-years or more post-secondary education diploma cycling almost twice more than the average (4.6% of declared local mobility trips against 2.6%). However, the gender factor seems to be more important in the French context, as biking accounted in 2019 for 3.7% of the trips declared by men, against 1.5% for women (SDES, 2019). In the Netherlands, data suggest a difference between residents from a non-western immigration background, for whom bicycles account for a share of 21% of the total number of trips, against 27% for the rest of population (Harms et Kansen, 2018), although this difference tends to narrow. Interestingly, in the Netherlands, women tend to use bikes a little more than men, with a share of biking trips in the total trips of 29% and 27% respectively in 2022. Latest data in the Netherlands also suggest that the advanced level of biking touches all parts of the country, although it is increasing with the level of urban development: the share of cycling in the total number of trips reaches 31% in highly urbanised areas, but it still represents 28% in

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very and moderately urbanised areas, 26% in the scarcely urbanised ones, and only 23% in the most rural areas (De Haas et Kolkowski, 2023).

In places where biking is particularly advanced and monitored, such as the city of Amsterdam – where the modal share of biking in trips from, to or inside Amsterdam by residents reaches 38% on an average working day (Gemeente Amsterdam, 2022), it was also found that biking accounted for 43% of the trips by residents aged 18 and over with a high level of education, against 30% for those with a middle level, and 22% for those with a low level. This is an important shift: in 2001, the respective shares were 29%, 33% and 37%. In Copenhagen, where biking accounts for more than 10% of the distances covered by the population for its daily urban mobility, the share of biking in personal mileage is 10% for people with the lowest income, against 18% for the middle-class[28] (DTU, 2023).

Nevertheless, there appear to be very strong differences between countries when it comes to the popularity of biking amongst the population, in terms of the number of persons who cycle on a frequent or regular basis, or never cycle at all (European Commission et al., 2017). According to survey data about the cycling frequency in Europe, in 2013, the share of people declaring to cycle on a frequent basis (from a few times a week to more than once a day) was of 18% in France, 26% in Italy, 33% in Latvia, 44% in Germany, and 56% in Denmark (respectively 13% + 5% in France, 13% + 13% in Italy, 19% + 14% in Latvia, 25% + 19% in Germany, and 26% + 30% in Denmark). The average in the European Union was 29%, and the record was reached in the Netherlands, with 71%. Conversely, from less than 20% in Denmark and around 30% in Germany, up to 55% in France and 60% in Italy declare that they never cycle.

These differences clearly go beyond socio-demographic deviations between the countries, whether it is in terms of age, income or education. It is therefore concluded that distinct cultural and political contexts on a national level play a bigger role in the trend, compared to differentiated socio-economic dynamics within the population. The same is true when looking at the differences that exist between cities. For instance, in a 2015 survey, the share of respondents who most often use bikes as one of their two main transport modes for their daily mobility was above 50% in Amsterdam or Copenhagen, when it remained below 10% in most of the cities covered (European Commission et al., 2017). The difference is significant both with all other European capitals, with all but these two recording a level below 20%, and a majority of them below 10%, or with comparable cities (17% in Stockholm, less than 10% in Brussels). Such differences could not be explained, even if they can play a role, by socio-economic or socio-demographic differences alone.

It can be concluded that, although gender, age, education and financial conditions all appear to influence the distribution of modal split in the local population, the main drivers seem to be the influence of the local and national contexts, as well as the various ranges of supporting policies that have been implemented over time.

Guidance target

Compared to the other sufficiency levers considered, the shift to biking in daily mobility has already taken place on a large scale, providing valuable experience to set a guidance target. Examples exist of places where policies and structural changes have delivered on a large level of such modal shift. They all show that such implementation, while not ironing out all socio-economic and demographic differences (but possibly changing them to some extent), creates differences in the average share of biking in trips and distance that go far beyond these changes in the distribution of biking practices between population categories.

The most prominent examples come from big cities like Amsterdam or Copenhagen, where 38% of daily urban mobility trips and 10% of the related distances are made by bike (Gemeente

[28] The categories used are people with an annual income lower than DKK 150,000, and between DKK 151,000 and 250,000. The share decreases to 12% and even 9% for higher income categories, likely not because they cycle less, but because they cover longer distances in total.

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Amsterdam, 2022; DTU, 2023). This level is also achieved in smaller though still large towns, like Freiburg in Germany, where the share of journeys made by bike in the city rose from 15% in 1982 to 27% in 1999 and 34% in 2016, while the population grew from 183,000 to 227,000 residents (*Buehler & Pucher*, 2011; City of Freiburg, 2024). Other examples, such as the cities of Sauda or Klosterøya in Norway, show that significant results can be reached also for smaller cities (Hagen et al., 2019, Hagen et Rynning, 2021). Moreover, the example of the Netherlands illustrates that while on average 28% of local trips are made by bike at the national level, this is not only an urban phenomenon, as the average is only down to 25% in less densely populated areas.

All in all, it is therefore chosen to set a similar guidance target for all five countries, corresponding to the best level observed, i.e. amounting to a biking share of 30% of all trips in daily and urban mobility, and 10% of distances covered[29]. Therefore, rather than considering the possible dynamics across categories of the population to drive this sufficiency-related change, the analysis will focus on the dynamics and limitations of implementing at national and local level, in the five countries, the kind of cultural and structural changes that could lead to such a modal shift.

Barriers and enablers crossed with possible policies

The 2020 Eurobarometer survey on mobility and transports provides interesting insights on the willingness to change practices of the more than 26,700 respondents who travel on a daily or regular basis. When asked what are the reasons for using the main mode of transport they are choosing (with the possibility of up to 4 answers), comfort (42%), speed and need to reduce the time it takes to make the trip (41%), the fact that there is no alternative (34%), reliability (27%) and pleasure (22%) stand out, while price (18%), privacy (16%), safety (18%) are less referred to, and environmental reasons (10%) only come in 10th position (European Commission, 2020).

Meanwhile, in this 2020 survey, 59% of respondents who use non-zero-emission cars (more than 16,500 persons in total) say they would be ready to switch a significant part of their daily mobility to more environmentally friendly modes of transport (of any kind), while only 38% say they would not. All of the five countries studied in FULFILL show results close to that average[30]. When asked under what conditions they would be ready for such a switch, cost is cited as the main factor, with 55% of respondents saying they could switch if the alternative is not more expensive. Other main conditions include to be as available (41%), as fast (40%), as adapted to needs (37%), to rely on infrastructures meeting the needs (30%), or to be as safe with respect to accidents (24%). Only 3% of respondents spontaneously declare they are ready to switch to a more environmentally friendly mode of transports regardless of the conditions (European Commission, 2020).

Regarding the cost issues, there is no doubt that using a bike costs less than using a car and, in most cases, than using public transports. However, it must be considered that the cost of buying a bike, and to a lesser extent, the cost of maintaining it, might add to the cost of a car, for people who still need this mode of transport, even if they shift to biking for part of their trips. Modal shift can therefore increase if more affordable alternatives to the need to own and maintain a personal car are made easier. This is shown in the case of the Netherlands, where there are more bicycles than people, with 1.3 bicycle per person on average (De Haas et Kolkowski, 2023). In Amsterdam, the average number of cars per household was in 2018-2019 half of that of the

[29] The average distance covered in a trip based on bike is lower than that with a trip based on car, which is still the dominant mode. Thus, the share of bike in distances is bound, even when this share increases, to remain slower than that of bike in trips. In many cases, however, figures are only provided either in terms of share of trips, or in terms of share of distances, and not both. Examples of surveys and studies that provide both suggest that this 1 to 3 ratio is a conservative approach.

[30] The shares of respondents who use non-zero-emission cars and say they would and would not be ready to switch a significant part of their daily mobility to more environmentally friendly modes of transport are respectively: 59% vs. 40% in Denmark, 62% vs. 36% in France, 59% vs. 39% in Germany, 59% vs. 35% in Italy, and 58% vs. 40% in Latvia.

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country, with respectively 0.52 and 1.07, and the number of cars per person in Amsterdam has decreased by 5% between 2010 and 2018 (Gemeente Amsterdam, 2022). The correlation between a context or set of policies that reduce the need to own a car and the use of bikes is shown in the fact that, on average over the Netherlands in 2022, the share of cycling in total journeys was of 33% for people who do not have a driving license, against 23% for people with a driving license; similarly, the share was of 37% for people living in a household with no car, against 23% for people in households owning two cars.

The analysis also suggests that the time of travel can be an important factor. Although it might not suffice to shift, it is likely that the impact of shifting to bike on the travel time budget could be an important obstacle. This is related to distance, of course. In the Netherlands, biking is mostly important over distances from 0.5 to 1.0km (about 38% of all trips) and from 1.0 to 3.7km (over 40% of trips); it still accounts for more than 20% of trips from 7.5 to 10km, and only 10% of those from 15 to 20km, then much less for even longer trips (De Haas et Kolkowski, 2023). In France, the peak rate of biking share in trips, with 5.2%, corresponds to distances from 2 to 3km (SDES, 2019).

There already exists a large time-saving potential through modal shift – or, at least, the modal shift to bike would not have a negative impact on travel time. For instance, a study shows that up to 25% of car users in Paris area could decrease their daily travel time by shifting to bike, and 46% would not increase it by more than 10 minutes (Leroutier et Quirion, 2023). According to the FULFILL survey conducted in task 3.1, between 49% and 97% of respondents, depending on the 5 countries and the type of destination, declare that they live less than 15 minutes by bike from commercial, cultural, educational, recreational or health care facilities (FULFILL, 2023c). It must however be noted that their working place is, by far, the destination in their daily mobility that seems the most remote: only 21% to 36% say they live within 15 minutes' cycling distance of their workplace, leaving room for specific policies to improve this share.

Also, an important new factor that could allow to overcome certain time and distance limitations and expand the range of trips and distance that are convenient and fast enough by bike is the emergence of electric bikes (e-bikes), sales of which in Europe increased almost 8-fold between 2010 and 2020, from 588 thousand to 4,5 millions. They represented 20.6% of all bikes sold in Europe that year, mostly driven by a boom in Germany, where they accounted for 38.7% of all bike sales. The share was also significant in France (19.2%), Denmark (16.1%) and Italy (13.9%), with only Latvia (2.9%) lagging behind (CONEBI, 2021). Although the penetration of e-bikes on market is still too recent to finely assess and therefore project its impacts, first available data suggests that it has a positive effect on the range of distances covered by bike. In the Netherlands, in 2022, e-bikes represented less than 1/4th of bike trips over distances up to 5km, but more than 1/2 of trips over distances longer than 10km (De Haas et Kolkowski, 2023). It also accounted for more than 1/3rd of trips in the less urbanised areas, against less than 1/6th in the highly urbanised ones, or 1/3rd of bicycle trips of women, or 1/2 of the trips of people aged 65 or more, against 1/5th of the bicycle trips of men, and 1/8th of those of people aged between 18 and 30. In other words, it is already playing a role in expanding, both in terms of categories and range, the use of bikes in daily mobility.

Besides the two concerns of cost and time budgets, the availability, convenience and safety of biking infrastructures also seem to play an important role as a barrier to shifting mode when they do not seem to meet the needs, and an enabler when they exist. According to data gathered by the European Cycling Federation based on OpenStreetMap, a clear correlation exists between the ratio of segregated cycling infrastructures to main roads, which vary throughout the EU from 7% in Czech Republic to 78% in the Netherlands, and the share of biking in mobility (ECF, 2024).

As an important level of shift to biking as a daily mobility mode has been achieved in some countries, cities and local areas, there is both evidence of and confidence in the fact that effective sets of policies exist that can deliver on such level. These policies, that are already touched upon on a national level in a growing number of countries (ECF, 2023), could be reinforced and generalised at national and local level. They include, as a priority covered in every cycling strategy identified, the development of dedicated infrastructures, the expansion of cycle routes networks, and the improvement of road safety for cyclists. These are generally

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completed by dedicated, regular and permanent public investments frameworks, legislative and fiscal schemes to incentivise the use of bike (e.g. fiscal incentive to commute by bike), and policies covering the field of capacity-building at local level, pilot projects, awareness-raising campaigns, and exchange and promotion of good practices. Among various other options, these policies can address enhanced production and monitoring of data related to cycling, anti-theft measures, industrial strategies, and the development of digital tools to smoothen inter-modal flexibility.

On a local level, this could be completed by a concrete approach centred on the concept of bikeability, a multi-factorial action taking into account natural and place-specific preconditions (location, topography, weather…), infrastructures and traffic (cycling infrastructures and facilities, traffic conditions, speed limits and safety, accessibility…), urbanity (density, proximity, urban structure…), surroundings and activities to improve the quality of cycling, in a complementary way to the measures suggested above (Reggiani et al., 2022; Hagen & Rynning, 2021).

Trajectory for the whole population: quantification rationale and narrative

Based on the analysis of socio-demographic and socio-economic factors, obstacles and enablers, and the strong return of experience of policies, it is projected that implementing such policies can reinforce the share of biking in countries where it is already advanced (Denmark, Germany) and boost it in those where it is still low (France, Italy, Latvia). Indeed, we have seen in the previous section that existing policies supporting the modal shift to cycling, both at national and local level, have delivered a strong shift towards biking in daily mobility and have shown some potential to tackle some of the gender, education, age, cultural or income gaps in the capacity or willingness to change transport mode.

However, limitations linked to time of travel and bikeability improvement should be taken into account. At national level, they can be approached through a series of density-related factors (whose starting point values are given in Table 18 for the 5 countries):

- the density of population can play an important role, as it influences at the macrolevel the distances people have to travel on average to reach various destinations (workplace, shops, educational, cultural or leisure centres, etc.), or the potential of maintaining and enhancing the availability of these destinations within a reasonable biking travel time over the years through urban planning;
- more precisely, a useful additional indicator relates to the distribution of the national population over the territory according to the degree of urbanisation, distinguishing for instance the share of the population that lives in cities, in towns and suburbs, and in rural areas (Eurostat, 2022), where access to distributed workplaces and various facilities, as well as the availability of segregated cycling infrastructures, might be subject to different constraints and dynamics;
- the road density in relation to population density, which can therefore be approached by combining an indicator of road supply, in terms of average road length per person (m/cap.), with an indicator of road density on the territory, in terms of km of road per km2 (European Commission, 2022);
- and finally, the density of cycling infrastructures, which can be compared to the road network itself through a ratio of segregated cycling infrastructures to main roads (ECF, 2024), providing additional information on the availability of biking options, and the need to develop them.

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Table 18: Population density and population distribution regarding urbanisation, road density and cycling infrastructure density in the five countries (Eurostat, 2022; European Commission, 2022; ECF, 2024)

	Population density (hab/km²)	Distribution of the population re. urbanisation			Road availability and density		Ratio of cycling infrastructures to main roads
		Cities	Towns, suburbs	Rural areas	m per cap.	km to km²	
Denmark	139.5	32.0%	33.4%	34.6%	15,8	1.8	42%
France	106.9	38.3%	28.1%	33.6%	20,3	2.3	7.5%
Germany	235.5	36.1%	43.7%	20.3%	9.9	2.2	33%
Italy	198.6	35.2%	47.7%	17.1%	13.6	2.7	8%
Latvia	29.8	43.0%	21.8%	35.2%	27.3	0.9	n.a.

The five countries show quite different situations regarding this set of indicators. There is almost an 8-fold difference between the high population density of Germany and the low one of Latvia, which results for instance in the fact that although the latter provides almost 3 times as many roads per capita to its residents, its road network remains 2.5 times less dense than that of the former. The share of population living in rural areas is around twice as high in France, Denmark and Latvia as in Italy.

The national narratives are framed by a global assumption that, in the framework of sufficiency-oriented lifestyles, there are no strong incentives to develop the road network for cars, which is therefore assumed to remain stable. At the same time, it is assumed that strong policies can enable the ratio of cycling infrastructures to roads to develop by 2050, possibly to the point reached today by a country like the Netherlands, although this could still be modulated by each country's topography, compared with the very flat topography of this advanced biking example. We also need to take into account the pace of development of cycling infrastructure. Indeed, countries where this share is low today, such as France and Italy, and presumably Latvia, will certainly not fully catch up with the progress that could still be made in countries where this share is already around half that of the Netherlands, like Germany and Denmark. Moreover, the density of the road network and the density of population, which are not considered to change, are likely to remain limiting factors.

Taking all these factors into account, it is possible to differentiate for each country an aggregate potential for reaching the guidance target. The highest potential would appear to be in Germany, which benefits from important population and road densities, a relatively low share of population living in rural areas, and an already high level of cycling infrastructures. It would be a bit lower, but still significant, for Denmark and Italy: the former is more advanced in terms of biking promotion, but faces more limitations in terms of density, while the latter is lagging behind and needs to develop cycling infrastructures but could benefit from higher density and a higher level of urbanisation. France's potential is even lower, mostly because it is less densely populated, its population lives largely in less urbanised areas, and it is very late in the development of cycling practices and infrastructures. Finally, the potential seems even more limited in Latvia, which seems a little more advanced than France but could be more limited by its significantly lower density.

Results

These differentiated potentials are used to project a share of cycling in the modal split of daily and urban mobility, which is derived from the guidance target previously established. The number of trips by bike is therefore set at a maximum of 30% of all daily trips by 2050 for

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Germany, and a minimum of 22.5% of daily trips for Latvia, with intermediate levels of 27.5% for Denmark and Italy and 25% for France.

The trajectory between the starting point and this 2050 level would likely depend on dynamics that could play out differently over time and between countries. This would notably be the case for a combination of further awareness-raising campaigns and financial incentives, that could fasten impacts – especially in less biking-advanced countries, and infrastructures construction, that would take more time to be implemented and deliver – particularly in these same countries. As no clear view of the possible dynamics emerges from such analysis, it was chosen to project, by default, a linear trajectory in each of the countries.

Table 19 summarises the projected change of the modal share – shares of trips and passenger kilometres (pkm) – of cycling in daily and regular mobility for the five countries.

Table 19: Projected assumption for the modal share of cycling in daily and regular mobility in the five countries up to 2050

	Modal share* of cycling	Situation 2020	2030	2040	2050
Denmark	Share of trips	12%	17.2%	22.3%	27.5%
	Share of pkm	7.5%	8.1%	8.6%	9.2%
France	Share of trips	3%	10.3%	17.7%	25%
	Share of pkm	1%	3.4%	5.9%	8.3%
Germany	Share of trips	15%	20%	25%	30%
	Share of pkm	5.5%	7%	8.5%	10%
Italy	Share of trips	4%	11.8%	19.7%	27.5%
	Share of pkm	1.9%	4.3%	6.7%	9.2%
Latvia	Share of trips	8%	12.8%	17.7%	22.5%
	Share of pkm	2.2%	4.0%	5.7%	7.5%

* Share of bike / e-bike as main mode in daily mobility

Discussion on the assumption

There does not seem to be much to discuss regarding the theoretical potential to meet a high modal share of biking in daily mobility, or the fact that it could apply, though to different degrees, in each of the five countries and through all its population. Some aspects of the projection, relating to how much of this potential could be achieved, nevertheless need some attention.

First of all, the high entanglement of biking with all other aspects of daily mobility, from the availability of different options to changes in travel distances, calls for particular caution regarding the use of the *ceteris paribus* principle. On the one hand, whether the willingness to shift from car and the incentive to do so can effectively give priority to biking will depend not only on policies aimed at making it more attractive: it is the combined evolution of all modes across the whole range of policies applied to transport that will determine the balance. There might be a competition between shifting to bike, public transports or the pooling and/or sharing of smaller cars – which are also part of a sustainable strategy for transports, and therefore need to be developed. It is not clear, and would call for further research, to what extent the potential of modal shift towards these complementary options can add up, or whether some of them neutralise each other, and this could depend on the consistency of combined policies. On the other hand, the evolution of needs that can come through other policies, such as the development of telework, the change in shopping and delivery practices, etc. can bring

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important changes in patterns of daily mobility, whether it is in terms of number of trips, destination of trips, or distances covered, all of which might influence the potential for shifting to bike that is non-linear. In total, it might be argued that it is not just a matter of adjusting the projection of modal shift to biking to more or less push for alternatives or changes in mobility pattern: one might consider the possible impact of some combinations on the potential of this shift itself.

Second, another important issue lies in the particularity of this sufficiency scenario assumption, which relies on feedback from successful policies to project the success of replicating similar policies in places where they have been less advanced. While this existing return of experience is an asset for building an ambitious projection of this leverage, it might also come with a limitation that is difficult to discuss. In many cases, the economic and political conditions in which these policies had such an effect, through socio-demographic dynamics, were different (post-oil shock, growing economy, urbanisation, etc.). There is therefore uncertainty as to whether similar policies can reproduce the same impact under today's conditions.

Finally, the projection might be more dependent on technological options than others. This is illustrated by the uncertainty about the future share of e-bikes in cyclists' mobility. It could be argued that it will remain between 10% and 20% of the bicycles stock, where it seems to stand in the most active markets, for different reasons including the higher cost, or that it will come close to 100%, because of its convenience and thanks to a decrease of costs – or any share between those: in fact, there is not enough return of experience or similar examples to project one dynamic rather than another. This can, in particular, have an influence both on the global potential, as a widespread use of e-bikes could push the global potential of bike share in trips further than the guidance target, and on the 1/3 ratio used between the share of trips and that of distances, as e-bikes could increase the average distance that is considered convenient for bike trips. This concern can even be broadened when considering the potential for further evolution, beyond e-bikes, for hybrid possibilities, including secured and more efficient scooters, that may emerge. This could blur categories and reshape everyday mobility in a more profound way. Such effects could benefit from a faster pace than other structural changes, thanks to the fact that infrastructures developed today for cycling in its current form can probably accommodate other forms of alternative mobility over time, and that the rate of renewal of this equipment and its penetration into usage may be much faster, given the industrial lead times, costs and periods of use, than for cars, for example.

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2.7. Flying less

Table 20: Summary of the construction of the quantified trajectory for the "Flying less" scenario assumption

Perimeter of study	Passenger air mobility.
Indicators	Yearly passenger kilometres (pkm) for air travel.
Past trends	General growth of air travel from 2010, interrupted by Covid-19 with a slow recovery.
Population groups	N/A.
Guidance target	CLEVER corridor i.e. 600 – 1500 passenger kilometres per capita per year (pkm/cap).
Policies	Bans when train alternative alongside rail infrastructure development, frequent flyer levy and other taxations. Mostly mid to long-term impact, significant effect on domestic and intra-EU air travel.
Main elements underlying the quantified trajectory	Bans are modelled thanks to progressive distances from which flights are replaced by train. An additional reduction is applied based on a survey.
Main results	Pkm/cap in 2019 and 2050. Global reduction of average pkm/cap for the 5 countries of 43% between 2019 and 2050. Total pkm/cap in 2050 range from 917 to 3111pkm/cap depending on the country. 31% of pkm/cap of 2019 are shifted to train by 2050 on average for the 5 countries.
Discussion	Data to target frequent flyers unavailable, uncertain impact of the approximation regarding distances, probable threshold effects, too ambitious shift to ferries for domestic islands, limitations of the modelling of policies and measures, no consideration and description of impact on tourism sector and aviation industry.

Perimeter of study and relevant indicators

Aviation is a sector where sufficiency policies are decisive, if not indispensable, to reach compatibility with climate objectives, as demand is rising and decarbonisation options are uncertain and limited (Bows-Larkin et al., 2016). Air travel increase is not so much an effect of more access to leisure mobility given to the many, but more an intensification for certain population categories, i.e. rather an increase in travels than an increase in travellers (Demoli & Subtil, 2019), which raises equity concerns (Hopkinson and Cairns, 2021).

In this sufficiency assumption we look into the possibility of reducing passenger air travel by implementing several policies and measures. The target perimeter is domestic and international aviation for all countries in EU27.

The indicator used is pkm for air travel, distinguished between domestic, intra-EU, and extra-EU.

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Macro data analysis, past and present trends

Thanks to Eurostat data on passengers[31] we can extrapolate pkm data for domestic, intra-EU and extra-EU air travels thanks to several approximations and following a territorial approach:

- For intra-EU, countries are attributed departing passengers, to prevent double counting of passengers in the country of departure or the country of arrival. Arriving passengers could also be chosen, or half of both arriving and departing passengers. This choice is arbitrary and leads to similar results.
- For extra-EU, EU countries are attributed half the passengers exchanged with another country, also to avoid double-counting.
- Distances between countries are approximated by distances between capitals available in open data, calculated as the great-circles distances between two points thanks to their respective latitude and longitude[32]; except for domestic, where they are approximated by the middle of a given distance class, which disaggregation is supplied in Eurostat.
- Domestic passengers in distance classes over 1000 km are transferred to extra-EU (e.g. French West Indies, Faroe Islands, Azores, etc.). In particular, the distance class above 2000km, having no upper bound, was approximated by a calculation to minimise error between the deduced Final Energy Consumption FEC by country[33] and the FEC by country from Eurostat.

From this data, we observe that except for the years after Covid-19 and the subsequent restrictions of aviation, air travel has been increasing in the last ten years. There are important discrepancies between the 5 countries. The impact of Covid-19 is still observed in 2022. Except for Latvia, most air travel concerns extra-EU flights.

[31] Domestic: https://ec.europa.eu/eurostat/databrowser/view/avia_paodis__custom_9375353/default/table; Intra-EU: https://ec.europa.eu/eurostat/databrowser/view/AVIA_PAINCC__custom_9413701/default/table?lang=en;
Extra-EU : https://ec.europa.eu/eurostat/databrowser/view/avia_paexcc__custom_9415164/default/table?lang=en.

[32] http://ksgleditsch.com/data-5.html

[33] For this calculation, the plane efficiency was assumed to be 0,38 kWh/pkm, value taken from the CLEVER scenario (négaWatt Association, 2023).

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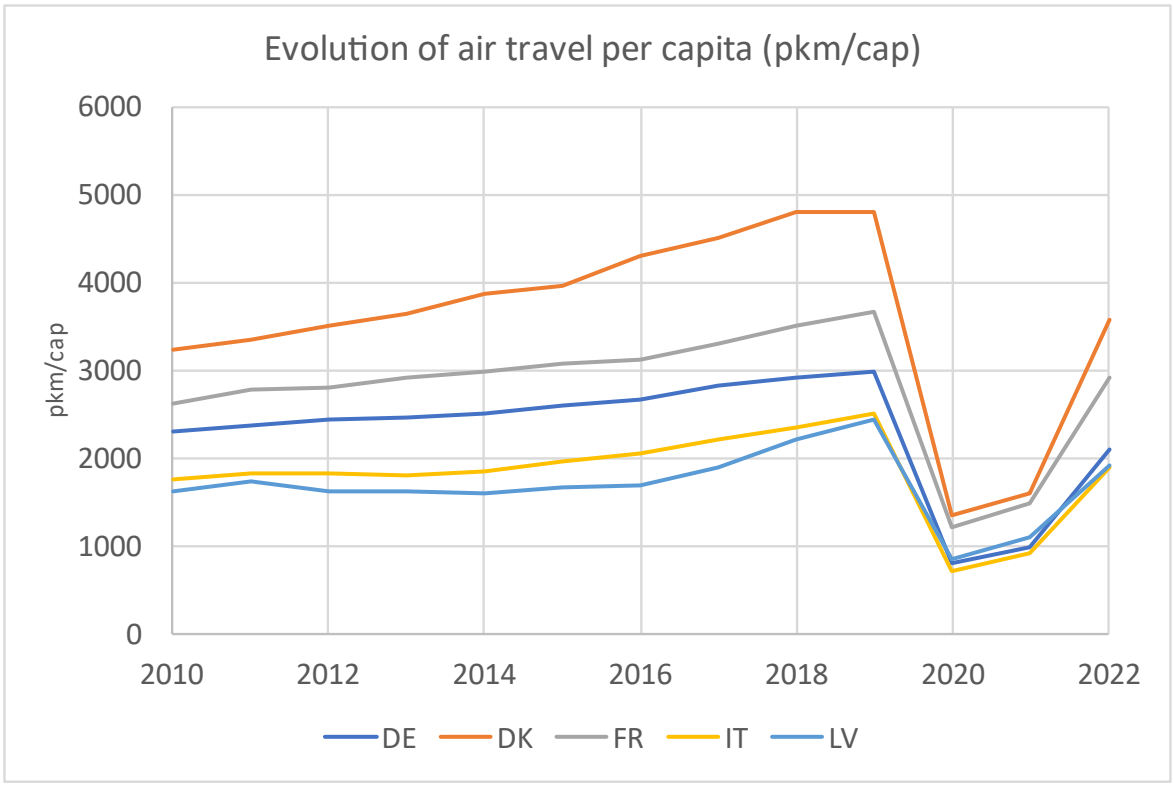

Figure 24: Evolution of air pkm/cap in the 5 countries studied from 2010 to 2022, calculation based on Eurostat data and distances between capitals

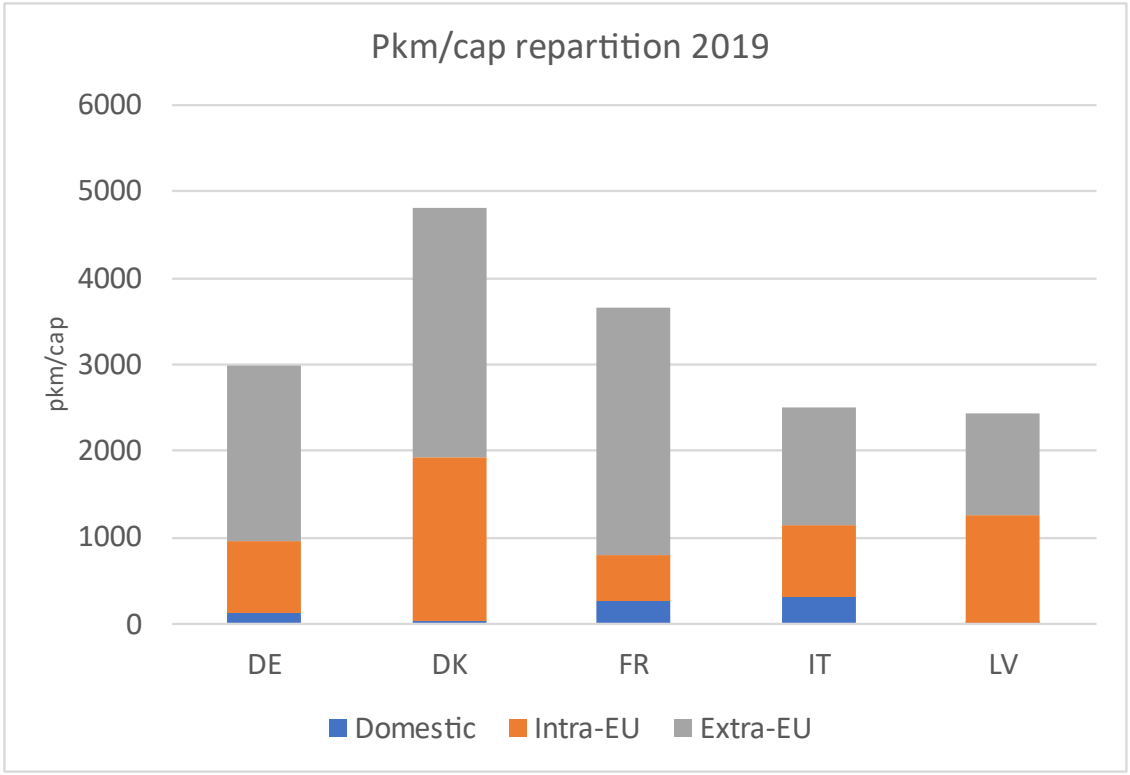

Figure 25: Air pkm/cap in the 5 countries by travel category in 2019, calculation based on Eurostat data and distances between capitals

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Insights from social science and humanities and main socio-demographic variables retained

Besides inequalities between countries, there are major inequalities within countries: only a small part of the EU population flies, and most flights are taken by a minority of frequent flyers that likely belong to richer, highly educated and urban households (Büchs & Mattioli, 2021; Hopkinson L and Cairns S, 2021).

Thus, a relevant indicator to form groups would be at least the number of flights per person, to reflect a sufficiency level and to study the evolution of this indicator with the impact of suggested policies. Income would also be relevant in a trajectory that studies an evolution of income distribution, and also considering that elasticity of air travel consumption might differ according to income.

Because of data and time limitations however, we could not form groups. Data on air travel frequency and distances was available in the FULFILL survey, however it was not representative: only 9% respondents flew in 2022 in contrast to 36% in FR in 2018, and 28% in EU28 in 2013 (Hopkinson L and Cairns S, 2021). Kilometres travelled declared were found to be quite far from Eurostat data: either respondents actually flew less because of Covid-19, and/or there exists a declarative bias. For example, about 30% of respondents who flew had a single one-way flight, which seems a higher share than expected, suggesting that some people might have declared one flight for a round trip instead of two.

Guidance target

We use CLEVER's scenario sufficiency corridor of 600 – 1500 pkm/cap per year as a reference to compare to our results (négaWatt Association, 2023, see mobility note).

Barriers and enablers crossed with possible policies

For this sufficiency assumption we use the analysis of the interrelation between change of social norms and policies that was carried out in the previous FULFILL T5.2 (FULFILL, 2023f), which includes barriers and enablers. We complete this by an additional policy analysis (see Table 39) to draw a trajectory.

The most impactful policy suggested is the ban of flights when a train alternative exists, as seen in FULFILL (2023f). Its impact is progressive in parallel with the assumed development of an EU rail network (European Commission, 2021). In France, it was estimated that the high-speed rail link between Paris and Bordeaux would have a carbon payback of less than 10 years if short-haul flights were banned on the same route (de Bortoli & Féraille, 2024), supporting the relevancy of policies to shift air travel to rail.

Other policies' impacts are more uncertain but at least one of them, the frequent flyer levy is supported by literature to be fair and effective (Büchs & Mattioli, 2024; Chapman et al., 2021; Fouquet & O'Garra, 2022).

The evaluation of the impact of suggested policies and their timeline was done by négaWatt in light of the previously quoted literature. Most policies can be implemented in the mid-term, but developing the rail infrastructure takes time and flight bans are progressive.

Trajectory with population averaged indicators: quantification rationale and narrative

As said previously, groups could not be formed for this sufficiency assumption. As a result, calculations rely on population averaged pkm/cap per country. Two main sets of policies are modelled: bans and additional measures.

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Flight bans when a train alternative exists

To simplify, hours proposed in the ban measure were translated to distances (see Table 21). From a given year, all flights within a country or between two countries for which the associated distance[34] is below the defined threshold are considered banned. The pkm/cap shifted to train are the ones from 2019. We choose to shift the pkm/cap instead of total pkm to take into account the evolution of population which is based on Eurostat baseline projection[35].

Table 21: Distances below which flights are banned for a given year

	2025	2030	2035	2040	2045	2050
Ban when a train alternative exists in less than x hours	3	5	6.5	8	8	8
Ban if < x km	300	500	1000	1250	1500	1500

The distance continues to grow after 2040 even though hours do not because rail infrastructure development is assumed to be complete in 2045. This creates a slight discrepancy between hours and distances.

There are exceptions where shift to train is not considered, in these cases there are no bans:

- Domestic flights with a distance above 1000 km, approximated as overseas as explained previously.
- All flights regarding islands in EU (IE, MT, CY) and Finland[36].
- All flights regarding countries outside EU30 (i.e. EU27, UK, CH and NO). Even though the shift to train seems possible to other countries neighbouring EU, it was not considered to be conservative. We checked that the impact is limited given current air traffic levels.

For these exceptions, the 5-year step air travel before applying additional measures (see below) is calculated by simply keeping 2019 pkm/cap value constant and taking into account the population's evolution.

Domestic flights to domestic islands (Corsica for France, Sardinia for Italy, etc.) were not considered as exceptions as they could be shifted to ferries. Thus, in our perimeter, this assumption is equivalent to a total shift to ferry (see discussion section).

Additional measures

Policies on frequent flyer levy and taxes provide an additional reduction to that provided by the switch to rail. They could not be modelled economically: instead, a global and uniform reduction is applied. This reduction is based on the survey by O'Garra and Fouquet (2022): the measured willingness to reduce air travel constitutes an average 23% reduction in distance travelled. We apply it on the remaining pkm/cap after the flight bans are calculated. In the absence of information on the possible pace of change, we consider that this additional potential reduction can be achieved from 2035 onwards, with a linear progression until that date.

[34] Either the middle of the corresponding distance class for domestic flights or the distance between capitals for intra-EU and extra-EU flights.

[35] https://ec.europa.eu/eurostat/databrowser/view/PROJ_19NDBI__custom_160151/default/table?lang=en

[36] Due to its particular geographical position in the EU, i.e. reachable by train only through Sweden, Finland was considered as an island.

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Besides, we assume that 30% of this additional reduction in pkm/cap is shifted to train.

Results

The reduction of the total average pkm/cap for the 5 countries between 2019[37] and 2050 is 43%. The highest reduction in pkm/cap is in Italy (61%) and the lowest is in Germany (38%). This could be explained mostly by the stronger reduction in intra-EU flights for Italy (88% versus 52% in Germany). In 2019, flights between Germany, Spain and Italy represented 21% of intra-EU pkm according to our calculations. But in our model, flights between Spain and Germany are not banned, contrary to flights between Spain and Italy, because the distance between Berlin and Madrid is over 1500 km, while the distance between Roma and Madrid is below. This shows a threshold effect (see discussion section hereinafter). There is also a difference in extra-EU pkm/cap reduction (36% for Italy versus 29% for Germany). Here the difference is narrower and more difficult to decipher. It is related to the proportion of pkm regarding flights to the United Kingdom, Norway and Switzerland[38] over pkm regarding flights to other extra-EU countries: respectively 17% and 7% of total 2019 extra-EU pkm for Italy and Germany. Thus, in our model, in proportion, more pkm are prone to a ban for Italy.

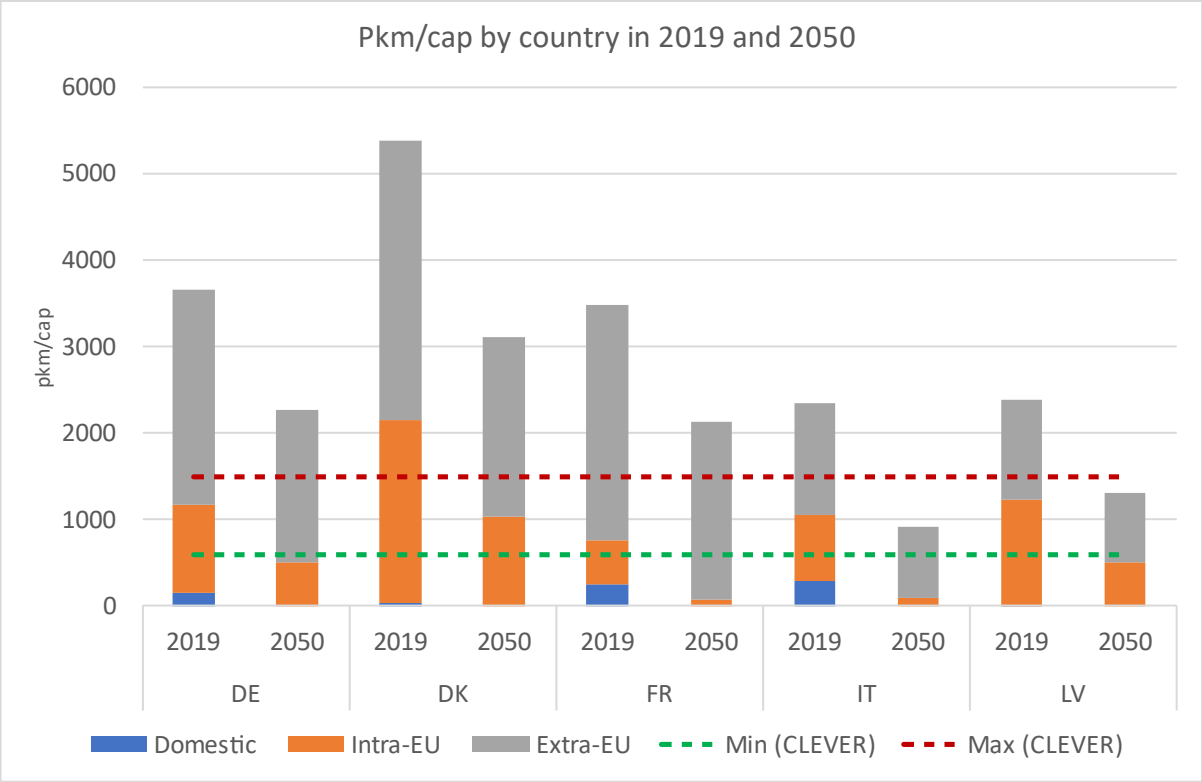

Figure 26: Pkm/cap by country and category in 2029 and 2050, compared with CLEVER's corridor

By construction, the model reduces pkm/cap but not in an equitable fashion. As expected with bans and a uniform pkm/cap reduction, countries with a high 2019 consumption level do not fall into the fair and sustainable consumption space suggested by CLEVER, mainly due to a limited reduction in extra-EU air travel.

[37] 2019 was chosen as a starting point since it was considered more representative because of Covid-19 consequences on air travel.

[38] These are the 3 extra-EU countries that are prone to flight bans depending on their distance to a given EU country.

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Discussion on the assumption

The unavailability of data on the number of flights per capita made it impossible to target frequent flyers in each country, and the population averaged approach adopted could not lead to equitable results. If we were to replicate this work, avoiding a normative target-based approach (using a common target corridor prior to building the trajectory), further research would be needed to achieve equity by strongly reducing air travel for frequent flyers and possibly increasing air travel for those who do not fly at all. The issue of economies heavily dependent on tourism should also be integrated in the discussions.

The impact of the approximations done to calculate distances was not fully evaluated. We checked that using the distance between capitals was approximately equivalent to using distance classes for intra-EU flights. However we do not know how close results would be using an approach by distances between airports. This is probably possible to calculate using Eurostat data and coordinates of each airport, but we could not do it because of time limitations.

As seen in the results section, there are probably threshold effects due to banning all flights between two countries based on distances between capitals. We can imagine that in more refined models, at least some flights between Germany and Spain would be banned. For example, if our model could differentiate distance between airports, flights between Frankfurt and Madrid would be banned[39].

The full shift to ferries for domestic islands was debated within the FULFILL consortium and was deemed too ambitious. However, this has little impact on 2050 total pkm value: at most 4% for Spain and Baleares considering current air traffic over 2050 total traffic. This could be refined by further research to evaluate to which extent shifting to ferries is relevant.

The 23% reduction in distance (measured from a willingness to reduce travels) used to model the impact of policies and measures adding up to the bans also has limitations as the survey was done in the UK only, and is declarative. It is therefore not certain that even with the suggested policies, people would react accordingly to the survey. Besides, the impacts of this reduction on other types of transport modes or even activities were not modelled.

The purposes of flights (business and leisure) were not investigated because of data limitations. Leisure flights may make up the larger share of flights, but frequent flyers may be business flyers rather than tourists (Hopkinson L and Cairns S, 2021), although this has to be confirmed for the 5 countries studied. This could be an important factor: at least one study proposed differentiating levies for business and leisure travelers (Chapman et al., 2021).

As with other sufficiency scenario assumptions, the impacts on the economy were not modelled, whereas we can assume that there may be consequences on the tourism and aviation industry of such sufficiency measures. Further research would be needed to assess these impacts, crossing them with the consequences of not curbing air traffic in terms of climate change mitigation and adaptation.

[39] As the distance between these airports is lower than 1500 km: https://www.distance.to/Frankfurt-Airport,Frankfurt,Hessen,DEU/Madrid-Airport-Terminal-1,Camino-del-Aeropuerto,28042,Aeropuerto,Madrid,Comunidad-de-Madrid,ESP

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2.8. Working less

Table 22: Summary of the construction of the quantified trajectory for the "Working less" scenario assumption

Perimeter of study	Society produces, works and consumes less
Indicators	Time required to adopt and maintain sufficiency practices related to sufficiency scenario assumptions, gender-gap in unpaid work.
Past trends	N/A
Population groups	N/A
Guidance target	N/A
Policies	Policies suggested either foster individual work time reduction (WTR) in line with a sufficient lifestyle or implement collective WTR at national level as a sufficiency policy.
Main elements underlying the quantified trajectory	N/A
Main results	The adoption of sufficiency practices may take time, but we suggest that most of the practices studied do not take extra time to maintain, except for the *"flying less"* scenario assumption. Gender-gaps are present in two of our chosen scenario assumptions. Sufficiency policies suggested might reduce these inequalities, but there could be also risks of increasing them.
Discussion	Considered perimeter is limited to draw conclusions; sufficiency and risks regarding gender-gap; the automation factor was not taken into account; perimeters of unpaid versus paid work were not challenged.

Perimeter of study and relevant indicators

Looking at the assumption on work time reduction (WTR) and energy sufficiency constituted an explorative work for FULFILL partners. This task diverged in scope, content and methodology from the other sufficiency assumptions analysed in T5.3, mainly because:

- This assumption is more complex than others, as it deals with both macro-economic and physical indicators and their interactions, as well as their joint evolution under the effect of WTR and sufficiency policies.
- This assumption is cross-sectoral, compared to others that are more restricted in scope, and its impacts are beyond the scope of the research design (see D2.1, FULFILL, 2023a), as WTR also affects the industry sector for example.

Why investigate work time reduction as a sufficiency driver?

Looking into IPCC reports and national climate and energy strategies from European countries show a lack of consideration for WTR as a potential solution in climate policies (Ibid). When analysing working time reduction policies implemented across Europe, it seems that none have been motivated so far by environmental objectives. WTR policies have been implemented to regulate workers' rights, to support economy policies, birth/fertility/family policies, health, retirement, mobility facilities, etc., but rarely for environmental causes (Pullinger, 2014).

However, results from quantitative and qualitative research achieved in WP3 and 4 called for further research to characterise the relationship between time constraints and sufficiency lifestyles. Time was mentioned by interviewees from D3.2 (FULFILL, 2023d) and identified

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multiple times as a key factor to engage into sufficiency lifestyle changes: *"One of the levers raised by respondents is working time reduction, for example through the 4-day week. Such initiatives require time, investment and eventually volunteering, which would be easier if the time dedicated to work was lower."*

Another reason why time appears connected with sufficiency is the fact that having more free time and the possibility of doing things more slowly is one of the main motivations for people to adopt a sufficient lifestyle (Ibid). People are willing to cut on their consumption habits in exchange for extra time. It is a narrative of a slower lifestyle that proves to be desirable, and thus is a lever for encouraging more sufficient lifestyles (Ibid).

Moreover, the growing literature on WTR intersects the scope of sufficiency as it explores its possible ecological, social, and economic benefits, the so-called "triple-dividend" (Hanbury et al., 2023a). Outcomes in terms of well-being and resource consumption are especially relevant for FULFILL. Regarding T5.3 and from a prospective point of view, it seems relevant to explore the transition to a society that produces and consumes less non-sufficient goods and services while improving quality of life and social justice through WTR. Distributions of working time, income and consumption and related inequalities are also issues that fall in the scope of sufficiency.

Conceptual framework

We considered three main concepts to support the narrative around WTR and sufficiency assumptions. The first one is the new consumer theory developed by Lancaster, which portrays well lifestyle changes at play in sufficiency behaviours in which the value derived from goods and services bought on the market increasingly comes from what consumers do with them (Lancaster, 1976). The examples collected in WP3 and 4 on diets or shared housing illustrate well how time becomes an important factor to switch to home-made, vegetarian, local-based diets, or to a house-sharing project. In both cases, we can observe value and satisfaction derived from this consum'actor lifestyle (Ibid). It also echoes the concept of political consumerism (Dubuisson-Quellier, 2000), which shows that consumption change towards sufficiency also requires time to think (about our needs, uses), learn, and produce. We relied on these concepts to look at how WTR policies could support the use of free time towards more active and sustainable consumption patterns.

The third concept used in the policy narrative is the *Eigenzeit* developed in the slow movement (Honoré, 2004). *Eigenzeit* aims at finding the right time and intensity for the right action, considering moments and contexts in which they are implemented (Ibid). This concept resonates well with the energy sufficiency approach where consumption patterns are evaluated against needs to find the "right" level of consumption. This framework also allows us to reconcile diverging positions on the relationship between WTR and environmental impacts, showing that a shift towards a sufficiency economy could lead to production and working time reductions in carbon-intensive sectors, but also an increase of activity and employment in the energy transition sector such as building renovation, agriculture, and renewable energy industry (Boulin, 2020).

Possible perimeter of a WTR-sufficiency prospective

To grasp what could be the area of study of a WTR-sufficiency prospective in T5.3, we consider in Table 23the possible goals of WTR on three levels, in the framework of sufficiency, and the associated issues at stake.

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Table 23: Goals of a WTR in a sufficiency prospective and related issues

Level	Goals of the WTR	Issues
Individual	Shift time-use from paid work to care time, voluntary work, discretional time. Increase well-being while reducing excessive consumption.	How to reduce the gender gap in care? How to limit the risks of energy-intensive rebound effects on leisure? Effects on income? Is the working time per person (WT/cap) coherent with the work needed to transition to and sustain a sufficient society?
Sectoral	Depending on sectors, increase/decrease total WT while reducing WT/cap in line with strategic/sustainable production.	How to finance sectoral conversions? How to apply WTR depending on production needs (4-day WW may not be suitable everywhere)?
Macro-economic	Reduce collectively/voluntarily production/consumption/WT while fine-tuning them depending on the type of goods and services (also looking at dependencies from imports).	Can we project coherent production/consumption/WT from physical and economic perspectives? Is a sufficient society feasible while WT reduces (some argue that a sufficient society requires more work)? How to consider innovations that may increase productivity?
	Reduce excessive expenditure while spreading access to decent living, along with redirecting consumptions with taxes and incentives	Financing the welfare state: can this economy ensure enough redistribution to provide expected minimum decent living? Are taxes enough to finance incentives, what happens when they reduce over time as consumption shifts towards tax-free products? How to redistribute income?

Thus, possible indicators could be:

- Working time: individual level, sectoral level, national level… its distribution between individuals, types of jobs, sectors, and its temporal distribution(s)
- Productivity and employment
- Time-use: paid work, voluntary work, care, discretional time
- Production and consumption volumes
- Types of goods and services produced/consumed
- Income and its distribution between individuals

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Insights from SSH and main socio-demographic variables retained to form population groups

Research evaluating the relationship between work time reduction, environmental sustainability, well-being, productivity, and employment is flourishing but shows diverging positions and methodologies on the topic. Given the focus of FULFILL on lifestyle and time limitations, we prioritised mostly literature addressing WTR at an individual level. But as said previously, other levels are crucial as well to study a WTR-sufficiency prospective.

Literature suggests that WTR has positive environmental impacts, but mainly through an income-expenditure reduction and not resulting from an engagement in activities that could be less resource-intensive (Antal et al., 2020; Hanbury et al., 2023a). A longitudinal study observed over 9 months that households engaging in a WTR reduced expenditures only for certain consumption items, such as clothing, with no effect on other consumption indicators, suggesting lock-in effects (Neubert et al., 2022). Regarding well-being and health, positive effects have been observed generally, even for lower incomes (Hanbury et al., 2023a).

In view of a WTR prospective within the sufficiency framework, the literature review suggests insights regarding the modalities of application of WTR policies.

Regarding the scheme of the WTR, a few studies suggest that a 4-day workweek has advantages: it could be one of the best WTR scheme regarding carbon emissions (King & van den Bergh, 2017) while mitigating risks of work intensification compared to a daily reduction (Persson et al., 2022). Then, addressing the question of whether a WTR policy should be applied with a reduction in income or not, a recent systematic review suggests that an income reduction with a wage compensation could be optimal for both environmental and social benefits (Hanbury et al., 2023a). Lastly, regarding the preference between a collective organised WTR versus a WTR on a voluntary basis, a collective scheme could be preferable considering gender equity as it could encourage more men to engage in care activities and reduce the gender gap in the labour market (De Spiegelaere & Piasna, 2017). We can suppose that if more men engage in unpaid work, the effect on the environment would be positive as parenting is a "*binding activity*" (Hanbury et al., 2019). Plus, a collective scheme would likely be more impactful regarding resource consumption than a voluntary choice engaged by a limited portion of population and might mitigate the observed risk of greater workload burdening the co-workers of those who engage in voluntary WTR (Neubert et al., 2022).

Groups

We look at which groups could possibly be useful in the framework of T5.3 to address a WTR prospective.

First, gender is relevant regarding WTR: there is a gender-gap in part-time work, as women work part-time more often than men and do so less by choice than men but more often for family obligations (De Spiegelaere & Piasna, 2017). Thus, it is not surprising to see in Eurostat data that women spend more time on productive unpaid activities (Eurostat, 2023c).

On top of that, the type of work is also to be considered, as WT differs by occupation, economic activity, etc. (Eurostat, 2024), and WTR could be for example differentiated for most exhausting jobs, overnight jobs, or atypical hours.

Lastly, income distribution is likely relevant as work time is correlated to income (Devetter & Rousseau, 2011), and would be useful in a WTR trajectory to capture a possible inequality reduction, especially if a WTR with a wage compensation as suggested in Hanbury et al., 2023a is applied.

Possible policies

Investigating the relationship between WTR and energy sufficiency brought us to consider the intricacies between economic and environmental impacts, well-being as well as multiple social and economic inequalities. In fact, looking more specifically at sufficiency lifestyles rather than

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carbon footprint adds another motivation for WTR policies beyond environmental lifestyle change, connected to well-being and reduction of inequalities. In this sense, Martin Pullinger emphasises that "*working time reduction policies have to fit within and respond to a wider socio-economic context and set of related policy goals*" (Pullinger, 2014), such as the global economy, competitivity issues, health policies, birth policies, etc., and encompass diverse variables at play:

- There are different working situations and conditions, with different lifestyle effects that one needs to apprehend (Hanbury et al., 2023b).
- Working times are strongly related to socio-professional categories and hide multiple social and gender inequalities (Pullinger, 2014).
- There are different time-uses with various carbon and energy intensities, so policies need to accompany WTR to encourage sufficiency-friendly time-use and avoid rebound effects (Ibid).
- WTR is strongly associated with increased well-being (Hanbury et al., 2023a), and needs to be taken as such as a motivation for WTR policies in a sufficiency approach beyond environmental impacts.
- Looking at income reduction impacts requires to consider the wider context of financial capitalism. Even though it is assumed that work remains a key determinant or provider of income, wealth also comes from other sources. WTR associated to income reduction needs to be associated to a redistributive policy system (Boulin, 2020).

Analysing existing schemes

The literature review showed different existing WTR schemes in European countries (although not supported by environmental objectives as for today), mixing collective and individual approaches, as well as different levels of action. The following schemes caught our attention:

- The life course approach, developed in the Netherlands and Belgium, where financial instruments allow to decouple the time when income is received from the time when work is done (Pullinger, 2014).
- 4-days work week, experimented in UK (4 Day Week Global, 2024), Japan (Nakamura, 2021), Iceland (Haraldsson & Kellam, 2021)
- *Freizeitoption* in Austria, where employees of concerned companies can choose between a 3% raise or 5h of WTR per month (Gerold & Nocker, 2018).

Important limitations were identified on most of these policy schemes. Inequalities, either social, professional or gender-based were not addressed. Also, voluntary schemes often recentre the decision of WTR at the individual level, rather than types of jobs; and has been shown to be a means to coping with poor working conditions (Persson et al., 2022). As said previously, there are risks of work intensification, either for the reducer or for their co-workers that did not seem to be taken into account, especially if the expected production per employee is not thought about.

Policy propositions

Explorative policy proposals were formulated at the macro-economic level (work, economic, and social policies). These propositions show that WTR policies should be built coherently with ecological and social policies to limit rebound effects or resulting social inequalities. The listed propositions are far from exhaustive and were intended as an introductory approach to support different WTR hypotheses. Limits and implementation conditions were not sufficiently analysed and would require additional research for non-exploratory work on the topic.

Based on the literature review, we considered different policy options between 1) an individual approach, in which although strongly incentivized by a legislative framework, individuals are free to decide whether to activate WTR, and 2) collective approaches, in which we distinguish a meso level (collective negotiations at the company or professional branch level, supported by a

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legislative framework), and a macro level where working time and income reduction policies would apply to all as a radical new economic policy (challenging financial capitalist system and the globalisation of economies).

Financial and environmental schemes to support individual WTR decisions:

Green life course approach: Martin Pullinger suggests the implementation of a "*green life course approach*", that would extend the application of existing financial instruments (e.g. Life course scheme in Netherlands and Belgium) to environmental activities (volunteering, house renovation projects etc) (Pullinger, 2014). Based on the same approach, the green life course scheme would allow to reduce or interrupt work over particular periods of time with financial support and the security to keep the same position once returning. The financial scheme managed at the State level allows to decouple time when income is received from time when work is done, through collective contribution (Ibid). Applied today to parental leave, childcare, early retirement, disability, sickness, unemployment, and training, it could also be mobilised for environmental projects (e.g. cohousing, repair café, plant-based food initiatives, etc.). To respond to limitations identified in life course schemes, Pullinger suggests a higher compensation system on certain social and professional categories to avoid inequalities in the use of the scheme, as well as to maintain the financial capacity to support the shift to low-carbon technologies (Ibid).

Environmental service or 'time budget': Supiot proposes a 'drawing right' mechanism to support care, training, or volunteering activities (Supiot, 1999), echoing the 'portable time budget' scheme under consideration in Germany (Boulin, 2020). We also link this proposition to a sort of 'environmental service', inspired from the French 'civic service' (ASC, 2024), that could be opened to all age and professional categories. This scheme would give the possibility to engage in one or two years 'environmental service', with State (or company's) compensation and security of job position once returning. Activities could range from volunteering in community/environmentally friendly projects to house renovation projects etc. The limit of such schemes is their inability to apprehend the time needed for 'daily' sufficiency (diets, care, household activities behind a renovation project), and the risk of resulting gender inequalities.

The *Freizeitoption* scheme, developed in Austria (Gerold & Nocker, 2018), also seems like a relevant policy scheme that could be extended to environmental activities. Since 2013, employees in participating companies are free to choose between a 3% income increase or a 5h work time reduction per month (Ibid). One could imagine that an environmental bonus could be implemented (e.g. allowing for 7h work time reduction) if employees engage in environmental-led projects.

In all these schemes, methodological complexity should be apprehended in the definition or categorisation of environmental projects.

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Collective WTR schemes:

Basic income combined with a personal carbon quota system: Boulanger suggests that the implementation of a universal basic income combined with a Personal Carbon Trading system is an effective way to reduce working time and to control for environmental rebound effects as well as social inequalities (Boulanger, 2010). This policy scheme presents multiple advantages: It delinks income from employment, which is a way to leave out the politically sensitive argument for continuous economic growth: job creation; it undermines the historically gender-based narrative that drives male workers to endorse the role of the economic provider of the household; it supports income redistribution and may facilitate the equal mobilisation of WTR between social categories. The provision of universal basic services has been suggested as an alternative to basic income (Coote, 2023) and could be considered instead in a collective WTR scheme. The carbon quota system, related to other climate and sectoral sufficiency policies, is an effective tool to orientate uses of free time and encourage environmentally friendly activities. Limitations are the complexity of implementation of a personal carbon quota system, as well as the limited plausibility of the implementation of a basic income system in the current liberal economic system. In addition, it does not cover the issue of income redistribution beyond work (financial capitalist system), which needs to be apprehended with other regulations.

Collective negotiations at the organisation's level to find the right working time: Echoing the *Eigenzeit* concept (finding the right time) from the slow movement, Boulin suggests to "*civilise times at work within internal collective negotiations*" between direction and trade union at the branch or organisation's level (2020). He cites the successful example of the Charity hospital in Berlin, where, following an intense social crisis, the direction engaged in collective negotiations with the Ver.di. trade union to define the "*right*" working time for care activities, considering employees' health, eliminating work overloads, and guaranteeing the quality of patient care (Ibid). Considering this successful example, one could imagine the implementation of national legislation obliging companies employing in the country to engage in collective negotiations with trade unions to define the right working time adapted to their activities considering economic, social, health and environmental objectives. This approach allows for better consideration of jobs' or industrials sectors' specificities for which harmonised working time reduction would not be relevant (e.g. in agriculture working time depends on the season and the weather).

Other collective schemes could be further explored, to better investigate the link between income reduction associated with the reduction of working time and redistributive policies. Overall, they pursue the same objective described by Boulin: think and organise work time in its relationship with other social times, so as to organise society and work beyond productivity and profitability objectives (Ibid). The collective value of care and volunteering activities should be better accounted for.

WTR in the context of the sufficiency scenario assumptions investigated in T5.3

In light of all previous remarks on the complexity of modelling this scenario assumption, quantifying WTR prospective impact was not possible in the context of FULFILL, as it would require a model that could quantify macro-economic and sufficiency indicators and their intricated evolutions.

However, as indicated in D3.2 (FULFILL, 2023d), engaging in sufficiency lifestyles takes time when looking at specific practices and/or initiatives – tiny houses, cohousing, community-supported agriculture, food-sharing, etc. –, it raises the question of whether this holds true for assumptions studied in T5.3 and to which extent. If so, then WTR could be seen as part of the sufficiency framework that fosters the assumptions studied. Besides, it seems relevant to evaluate whether WTR could have an effect on a possible existing gender gap regarding a given assumption, as gender has been found to be a salient determinant regarding inequalities in paid and unpaid working times (De Spiegelaere & Piasna, 2017). Eurostat data provides a quantification for 3 of the 5 countries on the gender-gap regarding unpaid forms of work (see Table 24).

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Table 24: Daily time spent in unpaid forms of work as main activity by sex in 2010 (Eurostat, 2024).

UNIT (Labels)		Time spent (hh:mm)	Participation time (hh:mm)	Participation rate (%)
GEO (Labels)	SEX (Labels)			
Germany	Males	2:26	2:45	88.3
Germany	Females	3:51	4:00	96.3
France	Males	2:23	2:55	81.8
France	Females	4:00	4:13	94.7
Italy	Males	1:43	2:27	69.9
Italy	Females	5:15	5:30	95.5

Quantification rationale and narrative

In the next sections, we try to answer the following questions: do the adoption and/or the maintenance of practices related to the assumption require more time; and is there a gender-gap regarding unpaid work related to the assumption, and if so, could it be reduced by suggested policies?

Diets

Additional time

We did not find data to evaluate whether following a plant-based diet takes more time than following an average omnivorous diet. Although it seems likely that changing habits to switch to a new diet takes time – as one needs to learn new recipes, possibly buy and cook new ingredients, etc. – we do not know if extra time is required in absolute terms for a plant-based diet compared to a meat-based diet. This seems difficult to evaluate as several factors besides the content in animal product of a given diet could impact overall cooking time, e.g. portion of raw ingredients, number of ingredients, cooking time per ingredient, etc.

Reducing the amount of "*ultra-processed food*" (Monteiro et al., 2013) in one's diet could certainly bring health benefits and thus fall in the scope of sufficiency. So, it seems possible that replacing ultra-processed food by home-made food could be a sufficiency practice that takes more time. However, policies suggested for this assumption (see section 2.1) could lead to an improvement of ultra-processed food – e.g. in France, Nutri-Score likely has pushed industries to improve the nutritional content of their products (Bauner & Rahman, 2024) – so it is uncertain to which extent health benefits would still hold true in this prospective. A diet containing ultra-processed foods – at least in small quantities – may still be healthy: in the study used to quantify food intake for the assumption on diets (section 2.1), convenience food intake of optimised diets (that fulfil nutritional guidelines) is only lower than current diets for one diet type (omnivores) and similar or even higher for others (Barbier et al., 2022).

From a resource point of view, comparing the same meal on the basis of its production mode (here home-made vs industrial) is not obvious, and may not favour home preparation as industrial production may benefit of economies of scale. Hence, we do not draw conclusions on the aspect of resource usage i.e. we do not know if cooking at home is less resource-intensive than consuming processed food all else being equal.

Gender-gap

Regarding the gender-gap observed on food preparation, national and Eurostat statistics provide figures for four of the five countries (see Table 25).

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Table 25: Average daily time spent on food preparation and dish washing by gender

Country[40]	Average daily time spent on food preparation and dish washing[41] (minutes/day)		Data collection year
	By men	By women	
France (Champagne et al., 2015)	24	66	2010
Germany (Eurostat, 2010)	25	59	2010
Italy (Eurostat, 2010)	21	109	2010
Latvia (Central Statistical Bureau of Latvia, 2005)	17	78	2003

As seen in Eurostat data and in Champagne et al., 2015, this gap is not counterbalanced by other unpaid work carried out by men, overall resulting in more unpaid work for women on average. Reducing men's WT could be an opportunity to reduce this gender gap, if supported by policies such as the ones proposed in our quantification of the assumption regarding diets (see section 2.1). For example, education campaigns such as food discovery programmes (The Country Trust, 2024) could be experimented as a means to change beliefs on gendered roles.

We did not find data regarding grocery shopping; this could be added to the discussion along with associated travel time.

Sharing space in housing and cohousing

Additional time

Shared living can take different forms, while some are resident-led, others are managed (Clark, 2021) by an entity. In the case of managed shared living, such as house-sharing or co-living, we do not have data to understand whether these living conditions require more time than conventional ones.

In the case of resident-led shared living, D3.2 (FULFILL, 2023d) provides observations indicating that both setting up a cohousing project and sustaining it take time, e.g. *"the daily practice of micro-democracy can be difficult and time-consuming, while the management of the project is also made complicated by administrative burdens."* Firstly, it seems likely that if cohousing became more supported by policies, and more mainstream, the time needed to set up a project could decrease, however we cannot quantify with the available information if it could reduce so as to require no extra time compared to more conventional living arrangements. Secondly, time regarding community living organisational aspects and deliberation on joint decisions was not quantified in D3.2 (Ibid), this could be a question for future research and would need to be compared to more conventional households, as these likely need some time to address organisational issues and communal decisions as well.

[40] Data for Denmark was not found and was not available in Eurostat.

[41] For Eurostat data, we consider the sum of time spent on food management except dish washing, defined as food preparation, baking and preserving (Eurostat, 2008) and dish washing.

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Suggested WTR policies could foster cohousing as periods of time could be dedicated to building a community, renovating a building, etc. instead of working, as in the green life course approach for example.

Gender-gap

While we do not have quantified data on gender gap regarding unpaid work specific to shared living, care work has been observed in intentional communities to be more fairly distributed because of a higher awareness of social issues (Ibid).

Sharing products

Additional time

Similarly to sharing space in housing, estimating how much additional time is needed by sharing practices is difficult to assess as it depends on the products, conditions, habits, location, and facilitating tools (such as digital platforms). For washing machines, bringing the laundry to a neighbour or to a common laundry room requires some more time, although as mentioned in the "Sharing products" assumption (see section 2.4), it is reasonable to suppose that sharers will do less cycles per year. All in all, these two contradicting trends could offset each other. As a conservative option, we could assume that sharing will require 15 more minutes per cycle, meaning 40 hours per year.

Gender-gap

Regarding the gender gap, national and Eurostat statistics provide figures for four countries out of five (see Table).

Table 26: Average daily time spent on laundry by gender

Country	Average daily time spent on washing clothes (minutes/day)		Data collection year
	By men	By women	
France (Champagne et al., 2015)	1	6	2010
Germany (Eurostat, 2010)	2	11	2010
Italy (Eurostat, 2010)	0	9	2010
Latvia (Central Statistical Bureau of Latvia, 2005)	0,6	8	2003

It does not seem like the suggested policies for this sufficiency scenario assumption could reduce the gender-gap. There may even be a risk of increasing the gap if sharing washing machines induces extra organisational work that falls back solely on women (see discussion section below).

As said previously, collective forms of WTR could encourage more men to engage in care activities (De Spiegelaere & Piasna, 2017), however this is uncertain. Reducing the gender-gap on laundry could be the target of other gender-equality policies or cultural changes that were not investigated in this study.

Biking

Additional time

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Whether biking takes more time than other transport modes is a complex question. It likely depends at least on the mode compared to, distance travelled and urban type – as for example average car speed depends on the urban type. For example, data showed that bicycles were faster than cars in the city centre of Lyon, France, (Jensen et al., 2010) while this seems unlikely for longer distance trips in less dense areas. In our assumption, 80% of the shift to bike is done from car, so it should be the mode compared to. The number of people shifting as well as a disaggregation of distances travelled was not modelled in the task, so estimating a potential additional travel time was not possible. If disaggregation by distances travelled was available, we could approximate associated travel time by assuming an average bike speed, and estimate shares of potential bikers for whom travelling time would increase. But calculating this disaggregation is complex as it requires to make assumptions on prospective distribution of proximity to work in 2050. As a reference and as seen in section 2.6, it was simulated that in the Paris area (regional scale), 46% of drivers could shift to e-bikes (and marginally public transport) without increasing travel time more than 10 minutes, with a decrease in travel time for half of them (Leroutier & Quirion, 2023).

WTR policies could foster biking: for example, one could be granted a working time reduction if he or she comes to work by bike on a certain distance that is long enough to justify extra time.

Car sizing

Additional time

Car sizing could impact travel times, considering the context of car electrification: do long distance travels take longer with a smaller car – hence a smaller battery – because of more frequent charging stops? In a sufficiency prospective, one lever to reduce traffic would be to favour trains for long distance travels, so in any case it suggests that the overall impact would be marginal.

Another possible sufficiency lever that would increase travel time is the reduction of speed on highways to 110 km/h (but only marginally i.e. 8 minutes per 100 km for countries with a speed limit of 130 km/h on highways (négaWatt Association, 2018)), but it was not retained among the studied assumptions.

Flying less

Additional time

It seems likely that shifting from plane to train, as was considered in modelling this sufficiency scenario assumption, would increase travel time. As the average modal report was calculated, we can deduce the extra time required in 2050 corresponding to this shift by making several assumptions:

- There are 28% flyers on average in Europe each year (2014 data) (Hopkinson L and Cairns S, 2021), this number is kept stable.
- On average, trains replacing air travel have roughly a speed of 160km/h (European Commission, 2021).
- Plane speed is roughly estimated at 900km/h, as the cruise speed of a typical long-range plane such as the Airbus A350 is Mach 0,85 (Airbus, 2013).

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Table 27: Estimated extra time for flyers shifting to train with data from the "flying less" assumption

Country	Report to train for flyers in km/cap	Extra time in hours per year for flyers
DK	5765	30
DE	3259	17
FR	3244	17
IT	4415	23
LV	2836	15

This average extra time may not be representative, as there may be high inequalities of air travel frequency among flyers themselves (Hopkinson and Cairns, 2021). When quantifying, we did not have sufficient data to make assumptions on the possible redistribution of air travel. Further research on sufficiency could assess this redistribution, by using consumption corridors within countries – as the ones used between countries in the CLEVER scenario (négaWatt association, 2023).

WTR could serve as a compensation for this extra time resulting from bans, to increase the acceptability of such as policy. As an example, a company in France offers extra days off to employees to allow them to travel by train instead of flying (Les Echos Start, 2023).

Conclusion

If transitioning to sufficiency practices probably requires extra time, it is not obvious that maintaining these practices once adopted result in a net additional time, whether it is travel time or unpaid working time. One exception in our study is the shift to train where the outcome is clearer and quantifiable, although our quantification has limitations.

Gender-gaps exist at least in two of our chosen assumptions. Sufficiency policies suggested might reduce these inequalities, but there could also be risks of increasing them, suggesting that this issue should be looked at on a case-by-case basis.

Discussion on the assumption

There is no consensus in existing literature on the causality relationship between WTR and sufficiency. Existing literature on the topic is scattered around different fields, approaches, and methodologies, making it hard to compare analyses with each other (Antal et al., 2020). Investigating the specific relationship between WTR and environmental impacts is also a challenge as both WTR and energy sufficiency encompass multiple social, economic, and policy issues beyond environmental ones. We suggest that given the potential benefits of WTR and its links with sufficiency, this could be explored by further research dedicated to WTR to study its possible integration in prospective scenarios.

It remains unclear if sufficient lifestyles require more time in general, but we only explored a few facets of them. In general, we can easily imagine that WTR could foster sufficiency if conditioned to replacing paid work by *"binding activities"* (Hanbury et al., 2019) and other time-uses suggested previously as biking to work, engaging in initiatives, etc. This could have additional benefits if we consider spillover effects observed in the interviews (FULFILL, 2023d).

Regarding gender-gaps, sufficiency policies should take into account possible risks of increasing gender inequalities through unpaid work. These risks are exacerbated by the "*green-feminine stereotype*" (Brough et al., 2016) that makes it more likely that sufficiency lifestyle

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changes regarding domestic unpaid work (e.g. zero waste practices, plant-based meals, locally-sourced grocery shopping, etc.) fall inequitably under the responsibility of women.

On the other hand, sufficiency policies could be an opportunity to reduce gender inequalities on unpaid work, either as a co-benefit or more directly; this should be considered when designing policy measures.

Another important question not discussed in our assumption but related to unpaid and paid work that could be addressed in WTR-sufficiency prospective is the contribution of automation (Lehdonvirta et al., 2023). Should automation be favoured in sufficiency scenarios, regarding its possible contribution to unpaid and paid WTR (if productivity gains are transferred to time instead of money and fairly distributed)? This could be a discussion for further research.

Beyond these considerations, in this assumption, we did not consider possible evolutions of what is considered paid work versus unpaid work, while it could relate to WTR policies and gender inequalities.

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3. Research contributions and limits

In order to improve the modelling of sufficiency-oriented pathways, the research carried out has investigated and tested several methods, such as:

- Listing in detail the potential enablers, barriers, and applicable policies,
- Subdividing the population into sociological groups with varied trajectories,
- Refining the categorisation of practices to better depict progressive and non-linear transitions,
- Using existing best cases as inspiration,
- Considering synergies and consistencies between practices.

In this section, we discuss how far this work has contributed to overcome the risks and challenges primarily identified at the beginning of the FULFILL project and summarised in Chapter 4 of (FULFILL, 2022):

- Quantification limits,
- Need for harmonisation,
- Risks of excessive split between behaviours and technologies,
- Consistency and interactions,
- Excessive sectorisation,
- Sociological limits of population averages,
- Rebound and spillover effects,
- Insufficient promotion of co-benefits.

These risks have been taken into consideration at various stages of the applied methodology, especially by considering findings and recommendations from social sciences and scientists gathered within the FULFILL project. In some instances, progress has been made compared to other sufficiency modelling exercises. Yet, some of the limitations remain and others have been identified along the project. They are presented grouped by main topics, with recommendations for future research.

3.1. Sectoral *versus* lifestyle approaches

In our work, after internal exchanges within the team and careful consideration of the pros and cons, preference has been given to a conventional sectoral approach, although it has some disadvantages. A sectoral approach means slicing human activities into sectoral practices (mobility, housing, working, etc.) and splitting the analysis accordingly. This is the option used in most scenarios and pathways, as it is easier in terms of data availability, depiction of relevant policies, modelling and assessment of potentials.

However, a lifestyle is not just an addition of independent sectoral practices but a more complex interrelation between how someone lives, moves, consumes, works, etc., both on an individual level, and within collective structures of different nature. The material, social, and cultural worlds are intertwined, and it is this interrelation that defines everyday life and how it changes. A more consistent "*lifestyle approach*" to sufficiency scenario assumptions could have been tested, for example by subdividing first the overall population into lifestyle-based sociological groups and then setting assumptions on how the intertwined practices of each of the groups could change over time at various paces. It is likely that such an approach would provide a more suitable framework for studying cross-sectoral scenario assumptions, as was touched upon when reflecting on the working time assumption. However, it also raises strong methodological difficulties, notably the fact that there is no universally agreed typology of lifestyles, as well as

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complexities in finding precise data about these different groups and their starting points. This may be an interesting route for future research though, as such an approach would better reflect the essence and integrated dynamics of lifestyles.

A key challenge with sectoral approaches is to ensure a sufficient level of consistency between assumptions, since several of the practices they cover and the indicators chosen may be dependent or interrelated. It is unrealistic to achieve full consistency (as this would require a highly complex model), but at least consistency checks between sectoral assumptions can be useful to adjust the most obvious interdependencies. This has been empirically implemented to a certain extent in this project, through ex-post comparisons and adjustments between related assumptions, notably during the effort on the last one related to working time. Yet more elaborated methodologies could be beneficial to improve the approach in future research.

3.2. Navigating between accurateness and feasibility

One of the main objectives of this work has been to develop sufficiency-related projections, as required to build prospective scenarios and pathways, that go beyond population averages and a superficial depiction of practices, in order to test more refined ways of taking stock of the sociological diversity and improve the trajectory setting.

Yet, the constraints of data availability and modelling feasibility have limited this exercise to still relatively simplistic ways of subdividing the population into 2 or 3 groups, and the practices into a few subtypes to better reflect how people may switch from one to another. From a sociological point of view, this might be seen as unsatisfactory considering the variety of lifestyles and personal situations in the real world. Also, for each subgroup the modelling of the trajectory or practice shifts has remained relatively straightforward without taking into consideration all the potential interactions between sociological, technical, and cultural aspects that play combined roles on practices.

As a consequence, our results should mostly be seen as exploratory and incomplete, and an invitation to pursue this stream of research and spend more time and resources to refine and improve the methodology. Each of the assumptions covered would likely deserve its own full research project, with more efforts to find or produce specific data and build more intricate sociological subgroupings and depictions of the impacts of the various aspects that drive sufficiency change.

3.3. Overcoming data limitations

In this study we often faced data limitations that played a key role in quantifying scenario assumptions. Below are suggestions for data collection or availability that could improve the refinement of sufficiency scenario assumptions.

- Data was sometimes missing at EU-level or in some of the covered countries. We had to use existing national data This explains why in some cases French field data or surveys were extrapolated to other countries, thereby adding uncertainty and obscuring potential cultural differences. Developing quantitative and qualitative surveys regarding the many aspects of sufficiency would be useful for future EU-wide projects.
- Existing disaggregated data is not always made available by statistics bodies and scenario modellers, either not published at all or not easily accessible. But the degree of data availability is very determinant to build scenario assumptions. Spreading practices of opening datasets would be very useful for modellers. Access to anonymised survey data could be generalised while keeping raw data only on request on a case-by-case basis.
- When data is available, it may be published in ways that hamper cross-variable treatment (e.g. by gender, revenue, age, etc.). This makes it impossible to cross a given indicator with several variables at the same time, which limits the

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disaggregation into social groups. It would be interesting for further research to have access directly to the original dataset. Besides, it could improve the forming of groups by unlocking the possibility of running more advanced statistical methods.

- Distribution data regarding sufficiency indicators was often not available for data that was found outside the FULFILL survey. Developing these kinds of datasets would be useful for further sufficiency research: to show the degree of discrepancy in a given population, to better define excessive and insufficient levels of consumption, to infer a consumption corridor, to form groups relating to their level of sufficiency, and to project the convergence of different levels of consumption into a defined corridor (this list may not be exhaustive).
- The confidence level of the data used was implicitly taken into account when building the scenario assumptions (e.g., gender was chosen over other variables in the "Diets" scenario assumption partly because it was estimated to be a more robust finding compared to differences regarding other variables). It could have been useful to assess and express in a systematised way the confidence or certainty level of each data (using e.g. the IPCC method to *"evaluate and communicate the degree of certainty in key findings"),* by evaluating the evidence's robustness and the level of agreement (Mastrandrea et al., 2010). This would clarify the confidence level of each step of the trajectory building, however it requires a considerable additional amount of work that was not available for this research. Nevertheless, we have mentioned informally in many instances some indications about the level of confidence of our data and calculations, especially where we had the most doubts.

3.4. The arduous choice of indicators

Even in a sectoral approach (in principle easier), the selection of indicator(s) to adequately reflect the analysed sufficiency scenario assumptions is challenging. Official statistics have generally not been built to reflect specific sufficiency aspects (such as sizing and sharing practices), and established indicators that relate to energy/resource consumption usually encompass both efficiency and sufficiency. Besides, indicators are sometimes provided with limited (or highly standardised) sociological disaggregation, making it difficult to implement the approach chosen in this research and to reconcile the available numbers with more refined field or qualitative studies from social sciences. This is certainly a serious limitation, which could be reduced, if not overcome, through the progressive adjustment of categories used in future statistics and surveys, such as those routinely conducted to monitor trends at national level, to better fit the needs of this approach.

Another difficulty lies in the level and perimeter covered by the indicator. Some indicators, such as square metres per capita, are interesting to reflect and measure sufficiency overall in housing (and are often used in scenarios and quantifications), yet they may mix several sufficiency practices and aspects that make it difficult to distinguish the role of specific practices and/or policies. For instance, average square metres per capita may evolve due to numerous drivers (higher space sharing, construction trends towards smaller dwellings, changes in family structures, need for extra space for teleworking, etc.), which themselves depend on different, and to some extent independent dynamics and related policies.

The choice of indicators for the scenario assumptions covered in this report has triggered long debates within the modelling team and compromises have been necessary between reliability and feasibility. These compromises are not always fully satisfactory. Sometimes it has been necessary to use rough guesstimates on some values in case statistics were not fit.

This limit **calls for official statistical bodies to enrich their datasets and consider sufficiency and lifestyle changes** to a higher extent in their work. It is interesting to note that some

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announcements have been made in this sense by some of these bodies such as ODYSSEE-MURE[42].

3.5. Limits of target-based trajectories

Most climate and energy scenarios including sufficiency elements use target-based rather than trajectory-based methods (see an analysis in FULFILL, 2022). In such an approach, a sufficiency-related indicator is assumed to reach a certain level by 2050. This level is guesstimated based on the consideration of the various levers and barriers or set as an ideal objective. The rest of the work then consists in building a list of the necessary policies, which are assumed to have the potential to reach the target, and derive from it a trajectory deemed as credible as possible to link the starting point to this end point. This approach seems especially fit to a framework where the 2050 target is supposed to be enshrined in a policy goal (e.g. national 2050 target).

However, it also introduces a high level of normativity in the methodology as the 2050 target is likely to influence the subsequent work of trajectory-setting. It may lead to over-optimistic estimates and trends and unrealistic or questionable choices to ensure that the trajectory eventually reaches its end point. The opposite would be a purely trend-based trajectory without any guiding horizon, built upon consideration of annual pace of change irrespective of where it eventually leads to by 2050. This approach also has its limits, since it may induce underwhelming trajectories that resemble business-as-usual and underestimate the full potential of the studied scenario assumption.

The most adequate methodology could be in blurring the distinction between target-based and trend-based and using an iterative navigation between both. This may be done e.g. through first setting an indicative guidance target (reflecting a policy goal and/or an ultimate level of physical/sociological constraints) but revisiting regularly this 2050 point during the design of the trajectory. This cyclical approach may help find the right balance between too much and too little normativity. This method has generally been implemented in this research, although in a rather implicit manner without documenting each and every iterative step that has led to the final result, and a different balance (typically depending on the existing level of normativity that already frames the dynamics linked to each sufficiency lever considered). A more detailed depiction of the process could have been useful, however lengthy.

3.6. Upscaling from a sufficiency scenario assumption to a sufficiency-oriented pathway

In this exploratory work, the methodology was developed at the scale of sufficiency scenario assumptions and for specific and quite disaggregated indicators. If it were to be replicated to improve the modelling of decarbonisation pathways, one should consider some critical concerns in this upscaling process.

The first issue relates to the consistency of an aggregate impact that would result from a series of actions projected through separate sufficiency levers that are mostly discussed *ceteris paribus*. When integrated into an overall, comprehensive scenario, some of the changes that are projected in this way could interact or overlap, with possible trade-offs and synergies that would need to be characterised. As shown by some of the points discussed for each of the sufficiency assumptions projected in this report, the proposed methodology allows, through its step-by-step approach, to identify and discuss some of these interactions. The next step, which could not be conducted as part of this task, could be to use this material as feedback to assess the cross-effects between some of the considered sufficiency levers and group dynamics, and revise the projections accordingly.

The second issue is that, further to the previous section 3.5, this lever-by-lever approach would result in an aggregate impact that does not necessarily meet the level which would be expected

[42] https://www.odyssee-mure.eu/publications/policy-brief/energy-sufficiency.html

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from sufficiency levers when constructing a lifestyle scenario to meet the 1.5°C objective. Indeed, for each of the selected sufficiency scenario assumptions, the search for the right balance between too much and too little normativity was carried out without having the overall view offered by the construction of a comprehensive scenario. Therefore, it cannot be assessed whether they are set at a level that meets the overall objective. This uncertainty could be reduced by increasing the number of sufficiency assumptions covered, but a potential gap could remain.

This issue could be addressed, particularly when only a few levers are studied, by comparing the results with the levels achieved for the same sufficiency levers in existing scenarios that propose sufficiency-oriented and 1.5°C-compatible pathways using a target-based approach. This may prove challenging, however, as they would likely use more aggregate indicators or describe sufficiency levers on a less specific perimeter (see section 3.4), making it difficult to interpret their trajectories with the same disaggregation level and perimeter for a consistent comparison. Such work was conducted as the first step of the next work package, in T6.1 (FULFILL, 2024). Nevertheless, the project schedule did not allow time to implement iterative navigation between T5.3 and T6.1, and the work presented in this report could therefore not be informed by feedback from the impact assessment carried out in WP6, which would have enabled further assessment of the usefulness of this comparison.

A final issue concerns the effort sharing between countries. A target-based approach allows to determine targets according to each country's starting points and capacities. We have seen in section 3.5 that such an approach can be enhanced by iterative navigation between target-based and trend-based approaches, making it possible to conciliate set objectives with the practical feasibility of transformation. This discussion, which focused on the conditions of implementation in each country, should also take into account the concern for a certain consistency between national trajectories. We could mention in this regard the convergence corridors approach adopted in the CLEVER scenario (négaWatt Association, 2023), which consists of defining consumption-corridors towards 2050 for major indicators, bounded by "*a lower threshold based on 'decent living' and an upper threshold representing a level of services compatible with a 1.5°C global warming trajectory*". However, as explained above, the indicators studied in T5.3 were too disaggregated and specific to allow for a comparison with such corridors. The T6.1 upscaling work from such indicators to per capita consumption levels could inform a readjustment process of the results presented in this report. However, due to the material impossibility of carrying out an advanced iterative process between two work packages, we were not able to consider a fair effort sharing between countries in the methodology.

If this work were to be replicated, we would suggest carrying out ex-post corrections to take into account the feedback from the impact assessment of the sufficiency scenario assumptions studied.

3.7. Lifestyle change in a changing world

When building a trajectory reflecting an evolution of practices or a policy impact, it seems generally preferable to suppose all other things equal in order to isolate and better measure the specific potential of what is being analysed. Yet, this *ceteris paribus* approach may sometimes sound artificial. Supposing some sectoral sufficiency developments in a society that would otherwise remain unchanged for all the rest is questionable, especially when it comes to levers and perimeters as specific as those examined in this task. As well as supposing that none of the current societal trends (ageing, gender balance, digitalisation, etc.) continues to spread.

In this project, a balance has been sought. On the one hand, economic growth, societal stability, and the socio-economic distribution and structure of the population (according to income, gender, household types, etc.) have been considered unchanged throughout the period. On the other hand, some specific trends have been considered in several ways:

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- General trends that cannot realistically be frozen have been systematically included in the modelling, such as national demographic projections till 2050 (according to Eurostat), the natural progress of technical energy efficiency, and a few others.
- We have considered that, as sufficiency practices spread in our trajectories, a certain convergence of practices by sociological groups occurs, thus reducing the stark differences that could exist at the starting point (between gender, age groups, etc.), in order to reflect the impact of massification and mainstreaming. However, this has not been done in a predefined and structured manner.
- We have considered rebound effects to some extent, although we have not addressed them directly. We have rather tried to identify where there might be some risks of rebound effects and have assumed in the trajectories that public policies were implemented to counter/limit these effects. However, we have sometimes made some broad recommendations for avoiding the potential rebound effects identified for certain sufficiency assumptions.
- The trajectory building assumes that sufficiency practices and policies take gender equality into consideration, so that sufficiency progress comes hand in hand with progress on that front too (e.g. better consideration for unpaid care work, division of household tasks, etc.). It could be argued that this is a weakness of this work, and that gender equality should rather be considered from the start and be at the core of the modelling exercise, and not just at the end of the process (through exogenous impact assessment), to ensure it also guides the construction of the scenario assumption.
- Similar consideration for social inequalities is more complex, and although it has been considered when reflecting on certain dynamics or appropriate policies, it has not been applied to the same degree. This is certainly a limit that would deserve further research to better integrate social justice into sufficiency modelling.

A better solution to consider the potential impact of exogenous societal trends could have been to run several sensitivity analyses on certain relevant variables. This however would have required more time than we had and could not be properly implemented in this research.

3.8. The reliability of declarative data

In order to estimate the level of acceptability and desirability of a lifestyle change towards sufficiency among the general population or specific groups, it is necessary to rely on data that often consists in surveys and opinion polls. Such data has been extensively used in this project, notably to build guidance targets and trajectories. However, they have two main limits. First, they reveal the current picture but seldom reflect how preferences could change over time (for instance when a sufficiency habit becomes more mainstream and popular among peers). Second, there is a documented intention-behaviour gap, especially for environmental behaviours.

This requires enriching declarative data by other types of evidence, such as in-depth qualitative interviews, field experiments, assessments of success stories, etc. Those studies should not only cover intentionality but also the preferred conditions for change. It also seems relevant to carefully design the way to ask the questions and provide context. In the FULFILL project, a substantial effort has been made to gather quantitative and qualitative data and material on the various ways sufficiency could progress at micro and meso levels, through practice changes, policies, local initiatives, etc. For each of the scenario assumptions covered in this T5.3, additional sources have also been identified and used. Nonetheless, the aforementioned limits of declarative data remain and should be kept in mind, especially when limited field studies could be found to back general surveys.

The short-listing of the eight sufficiency scenario assumptions covered in this modelling exercise has come at a later stage in the project after the human and social science field work

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had been completed in previous work packages and has obeyed to a number of criteria (saving potential, quantification feasibility, etc.) that has prevented a full alignment between both. It means that for some of the scenario assumptions the previous sociological material from the project was not fully exploitable or missing. A better alignment from the start of the project would have been beneficial to ensure that a larger part of the early work would serve to inform the modelling tasks.

3.9. How fast may a curve bend?

The less challenging sufficiency scenario assumptions are probably those for which a positive trend is already visible and some experience may be gained from existing practices and policies. Data and experiments from social sciences may be available to understand the drivers and help building a credible continuation of said trend(s). An example is biking to work, for which the tendency is already significant in numerous (urban) places and studies are available.

In opposite cases where the trends are not at all heading towards sufficiency at present, a reversion of the curve may sound much more suspicious, if not unrealistic. This is especially true when no policy has been designed or tested yet, and a change in the curve relies on assumed "*cultural shifts*" that are not visible today. History has taught us that seemingly incredible behavioural changes may eventually become reality under certain conditions. The well-known illustration is the reduction of smoking in public spaces, which could have been doubted but has progressed due to a combination of shifts in policies, preferences, cultural norms, etc. There is however no guarantee that a similar plan could work for any sufficiency practice. In that regard, it could be interesting for further research to look at very rapid changes or disruptions that occurred in the past – such as spreading of new technologies, new behaviours or new social norms – to understand their drivers, and to investigate whether democratic forms of governance could lead to radical changes via deliberation.

These uncertainties suggest remaining relatively cautious when assuming a bend in a curve, and building a strong case or narrative to justify the feasibility. This applies to sufficiency levers but to others as well: electrification, new technologies, etc. Care should be taken in the trajectory building to allow sufficient time for the transition to take place, e.g. through introducing a long period during which the flattening and reversion of the curve will take its time until policies or other levers of action eventually start having their full effect. It means for instance in practice to assume very moderate change during the next decade. This may be best reflected in picking S-shaped rather than the linear trajectories that are often applied in scenarios. In some of the scenario assumptions covered in this research, this aspect has been particularly taken into account. Although some readers will probably continue to regard some of these scenario assumptions as excessively optimistic – along perhaps with the goal of 1.5°C-compatible lifestyle changes – this work paves the way to a more in-depth discussion on the degree of feasibility of such projections and on ways of strengthening them. In this respect, it would be useful for modelers and scenario builders to be transparent and detail clearly the assumptions regarding rhythms of implementation of different action levers and their acceleration.

Furthermore, the perception of what is considered realistic and conservative by scenario builders is subjective and may be an important decision factor when making assumptions (Saujot & Weissman, 2020). Developing SSH work and representative citizen workshops on sufficiency seems a good starting point to go beyond representations of scenario builders, and feeds discussions on the realism of disruptive social changes.

3.10. Taking policy limitations into account

For each of the scenario assumptions, a number of relevant policies have been identified and are supposed to be progressively implemented so that the trajectories may reach their end points by 2050. This is the nature of assessing potentials, where one builds a contrasted picture against a business-as-usual scenario and assumes that the policies and measures are well-designed to reach their goal.

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However, policies are not always perfectly designed and may suffer from barriers and limitations. It was shown in FULFILL (2023f) that sufficiency policies sometimes face acceptance issues and turn out to be delayed and/or weakened compared to the initial intentions. For instance, taxation and financial measures may be revised or frozen after realising that they hit too hard certain population groups, or after protests, or in difficult economic times. Policies may also generate direct and indirect rebound effects, or unexpected social justice issues that will need to be corrected. One illustration is policies encouraging sustainable mobility that may incite people to travel more than they used to. Likewise, supporting greater access to shared and second-hand products could feed compulsive consumption habits instead of reducing them. However, in some cases, policies prove easier to implement or have a greater impact than expected. As the dynamics of global politics matter, we could assume that the balance between braking and accelerating effects could evolve positively over time, in a future where sufficiency becomes more mainstream.

In principle, it would be better to anticipate those issues and take them somehow into account in sufficiency-based scenarios and pathways, or to precisely specify the conditions and potential additional remedies that could be applied in case of trouble. However, it is certainly not easy to anticipate and quantify such issues and their future impacts and this has not been done in an explicit way in our work. We believe that the potentials that we have assessed are reasonable, but it is clear that they could shrink if some of the policies that we have considered were dropped, weakened or ineffective – just as they could increase if unforeseen synergies were to occur. Further research into sufficiency policies is also needed to shed more light on this issue.

3.11. The complex issue of cultural differences

One of the strengths of FULFILL is to gather data from and provide analyses for five different EU countries, contrasted in terms of sizes, characteristics, and cultures. The impact of national differences on sufficiency consideration and adoption has been discussed in FULFILL (2023e). Our intention was to reflect these cultural specificities in the modelling and trajectory setting. This has only been partially done, as it proved a complex and uncertain endeavour. Robust quantifiable data is often lacking, and the risk is high to rely on simplistic and unsatisfactory stereotypes. In the end, insufficient time and resources could be devoted to do a refined job. Nevertheless, some quantifiable differences could be taken into account, such as differentiated national starting points for the key indicators, existing policies in some of the countries, as well as national demographic characteristics and projections.

Yet, the more complex and less tangible impacts of other differences (such as political systems, economic vitality, cultural norms, etc.) were only implicitly and superficially considered or not considered at all. In some cases, it has been assumed that similar policies and changes would occur in the five countries and produce the same impacts, which is a limit. There is no guarantee that a success story in one country may easily be replicated in another. However, the proposed methodology can allow to identify a sufficient set of conditions, policy and measures to support the assumption that implementation could be tailored so that a similar trajectory could eventually be replicated. Also, for some of the scenario assumptions precise data was sometimes lacking in some countries and extrapolations from one country to another had to be made.

Further research on these cross-country comparisons would certainly be helpful to better reflect cultural differences in the trajectories, policies, and pace of adoption in EU-wide sufficiency scenarios.

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4. Concluding thoughts

This exploratory work was interesting in many respects. First, when building a sufficiency scenario assumption, it appears that **identification is key**. It is indeed important to understand the social determinants at play in the transformation of lifestyles towards sufficiency and to consider the barriers and enablers for sufficiency policies. This preliminary step allows, by identifying the targets more clearly, to better define the policy objectives and thus to design more tailored and effective policy instruments.

Besides, with more detailed policy work, the methodology developed would make it possible to outline a policy strategy by **articulating policies and measures for the short, medium and long term**. Integrating this temporal articulation of policies directly into the process of constructing the quantified trajectory matters both to strengthen the scenario assumption and to give a clear direction to policy makers. This interdisciplinary work seems of interest to reinforce the political credibility of sufficiency scenarios.

In addition, the suggested approach enables the elaboration of **relevant narratives** because it forces to describe precisely the social and political dynamics at work throughout the trajectory. This can contribute to **making sufficiency policies more tangible**.

The work carried out in this task turned out to be too cumbersome to be replicated for every single lever to consider in a sufficiency-based pathway. Nevertheless, one could imagine developing this work only on a selection of impactful levers, or using the methodology to go in-depth into sufficiency scenario assumptions that are causing social or political debate. In conclusion, this interdisciplinary research work is promising and should be deepened through a continued dialogue across SSH and prospective studies (i.e. techno-economic energy and climate research). It could serve as a basis to discuss how future sufficiency-based scenarios could be improved by using information from SSH and how qualitative or quantitative surveys could be developed for this purpose.

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Annex

Selection of scenario assumptions

Table 28: Results of scenario assumption scoring against chosen criteria

Lever	Ability to quantify	Research design	Link with previous WP & tasks	Socio-demographics	Impact	Diffusion	New content	Advocacy	Total score
Sharing products	4	5	4	3	3	2.5	4	1	3.3
Moderate car sizing	4.5	5	1.5	0	4	4	4	3	3.3
Sharing space in housing	4	5	2	5	5	3.5	2	4	3.8
Cohousing	2	5	5	4	3	2	5	1	3.4
Eating less meat & dairy	4	5	4	4	5	3.5	1	3	3.7
Biking	3	5	3	5	3.5	3	2	3	3.4
Flying less	5	5	3.5	5	5	3	0	5	3.9
Working less	4	1.5	4.5	4	0.5	4	5	1	3.1

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Diets

Policies

Table 29: Evaluation of the potential of policies according to existing barriers and levers for the "diets" scenario assumption

Barrier/Enabler vs Policies	Concern regarding breeding/slaughter conditions	Ethical concern of killing animals	Environmental concerns	Health concerns	Aversion to meat	Possible presence of antibiotics	High cost of animal products	Fear of nutritional deficiencies	Availability of alternatives in stores, restaurants, collective catering	Cost of alternative vegetarian products and fruits and vegetables	Sharing meals with others, social acceptability	Lack of knowledge of plant-based recipes or alternatives to animal protein	Taste enjoyment of animal products	Masculinity norms
Type	Enabler	Enabler	Enabler	Enabler	Enabler	Enabler	Enabler	Barrier	Barrier	Barrier	Barrier	Barrier	Barrier	Barrier
Redirect subsidies towards production of plant-based alternatives							++		++	+++				
Apply environmental objectives to food industries	+		++						+++					
Fair taxation and redistribution on food to drive changes							+++		++	++				
Implement vegetarian options in schools and collective catering			+	+					+++		++		++	
Free nutritionist check-up once a year				++	++	+		+++					+	
Integrate accessibility to healthy and sustainable food in social protection systems				+++				++		++				
Regulate food marketing and advertisement	++	++	+	+	++	+		+					+	+++
Labels informing on nutrition and environment			+++	+++		++		++	+			+		
Prevention campaigns to promote healthy and sustainable diets	++	++	+++	+++	+	+		++						+
Train professions in contact with the public to promote healthy and sustainable diets			+	+	++			++	+++			+++	+	+
Implement food and climate education programs in schools	+	++	++	++	+++						+++	++		++

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Table 30: Evaluation of the qualitative potential and their full-impact estimated date for the "diets" scenario assumption

Policies	Target Groups	Qualitative Potential	Full-impact estimated horizon	Comment	Year of impact in model
Redirect subsidies towards production of plant-based alternatives	All	NA	Potential effect: long term Feasibility: middle term	Time for reconversion of agriculture, as a first step in the supply chain	2040
Apply environmental objectives to food industries	All	NA	Middle term	Time for changes in industrial processes	2040
Fair taxation and redistribution on food to drive changes	All	A	Potential effect: short term Feasibility: long term	Quick reaction of consumers to prices but difficult to make acceptable	2050
Implement vegetarian options in schools and collective catering	All	B	Short term	Options directly available might facilitate the shift. Easy to implement.	2030
Free nutritionist check-up once a year	All	NA	Mid term	Impact uncertain	2040
Integrate accessibility to healthy and sustainable food in social protection systems	All	B	Potential effect: Long term Feasibility: Mid term	Relatively easy to put in place with minds changing progressively in the society with time but effects on the long run	2050
Regulate food marketing and advertisement	All	B	Mid term	Speed of reaction to changes in marketing might depend on the category of consumers	2040
Labels informing on nutrition and environment	All	C	Short term	Quick and easy to read information might lead to direct changes in consumption habits	2030
Prevention campaigns to promote healthy and sustainable diets	All	C	Short term	Soft measure which impact is hard to evaluate in time but is easy to implement	2030
Train professions in contact with the public to promote healthy and sustainable diets	All	C	Potential effect: Long term Feasibility: short term	Educational measures might take time to lead to substantial changes	2050
Implement food and climate education programs in schools	All	B	Potential effect: Mid term Feasibility: short term	Effects can be estimated to about half a generation (10-15 years) to grow up and change personal diets	2040

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Quantification

Table 31: Quantities of food intake per person by diet type in SISAE (Barbier et al., 2022)

g/d/p intake	Omnivore_170 g	Omnivore_75 g	Flexitarian_30g	Pescetarian	Vegetarian	Vegan
Animal products	515	372	292	238	151	4
Bovine and ovine meat	62	25	9	0	0	0
Pork, offal and others	73	33	14	0	0	0
Poultry	38	18	8	0	0	0
Dairy	291	253	222	190	151	4
Seafood	52	44	40	48	0	0
Vegetal products	994	928	1002	1316	1357	1776
Fruits	341	336	358	419	404	553
Vegetables	392	350	378	501	483	571
Legumes	32	38	66	162	216	370
Cereals	210	185	180	211	231	256
Oils	20	19	20	23	23	26
Other	1 125	1 047	1 056	1 139	972	804
Convenience food	39	30	24	21	27	23
Coffee tea chocolate	800	790	836	919	730	592
Alcohols	118	89	77	70	59	58
Non-alcoholic beverages	98	79	67	70	99	89
Sugar chocolate	11	10	9	9	9	9
Others	59	49	44	49	48	32
Total	2 635	2 347	2 351	2 693	2 480	2 584

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Table 32: Optimised diets from SISAE (Barbier et al., 2022)

g/d/p intake	Omnivore_ 100g_opt	Omnivore_ 45g_opt	Flexitarian_ 20g_opt	Pescetarian_opt	Vegetarian_opt	Vegan_opt
Animal products	264	182	142	104	66	4
Bovine and ovine meat	26	10	4	0	0	0
Pork, offal and others	32	14	5	0	0	0
Poultry	44	20	9	0	0	0
Dairy	136	116	103	78	66	4
Seafood	26	23	21	26	0	0
Vegetal products	705	868	1112	1352	1533	1247
Fruits	155	149	149	181	183	299
Vegetables	298	355	393	470	525	283
Legumes	72	142	348	536	585	433
Cereals	156	197	201	138	204	215
Oils	24	26	22	27	35	17
Other	459	436	511	596	493	463
Convenience food	16	20	26	28	63	56
Coffee tea chocolate	153	164	255	331	210	279
Alcohols	72	67	61	57	51	26
Non-alcoholic beverages	132	93	82	92	66	68
Sugar chocolate	9	7	5	10	10	9
Others	77	85	81	78	92	24
Total	1 427	1 487	1 765	2 051	2 092	1 715

Table 33: Approximation to derive shares of SISAE-based diet groups from FULFILL survey data

Approximated diet type shares (SISAE clusters)	Shares of red meat intake used
Omnivore_170g	Daily + 1-3 times per week
Omnivore_75g	1-3 times per month
Flexitarian_30g	Less than 1-3 times per month
Pescetarian	declared pescetarians (included in NA)
Vegetarian	Never + declared vegetarians (included in NA)
Vegan	declared vegans (included in NA)

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Estimation of the share of omnivores that switched to a flexitarian diet between 2016 and 2021:

27% of flexitarians declare changing diets more than 5 years before the year of survey (2021), and 30% of respondents declare being flexitarian in 2021. Thus, in 2016, the share of flexitarians could be estimated to 27% of 30%, i.e. 8% of respondents. With the same reasoning, we infer the shares of vegetarians, pescetarians and vegans to be of 2%, 1% and 0,4% respectively. Then, we assume to be conservative that newly (after 2016) self-identified vegetarians, pescetarians and vegans were flexitarians in 2016 and not omnivores (this minimises the number of omnivores switching to another diet). Thus, in 2016, the share of flexitarians could be estimated to 8% plus 68% of 3% i.e. 2% (pescetarians), plus 60% of 5% i.e. 3% (vegetarians), plus 79% of 2% i.e. 1.6% (vegans); thus a total of 13.6% of flexitarians. Adding the sum of 2016 estimated shares for vegetarians, pescetarians and vegans, i.e. 3.4%, results in 17% of non-omnivores, thus 83% of omnivores. By comparing to the 2021 share of omnivores i.e. 61%, we infer that 26% of omnivores switched to another diet, and in coherence with the previous assumption we assume that they all went flexitarian.

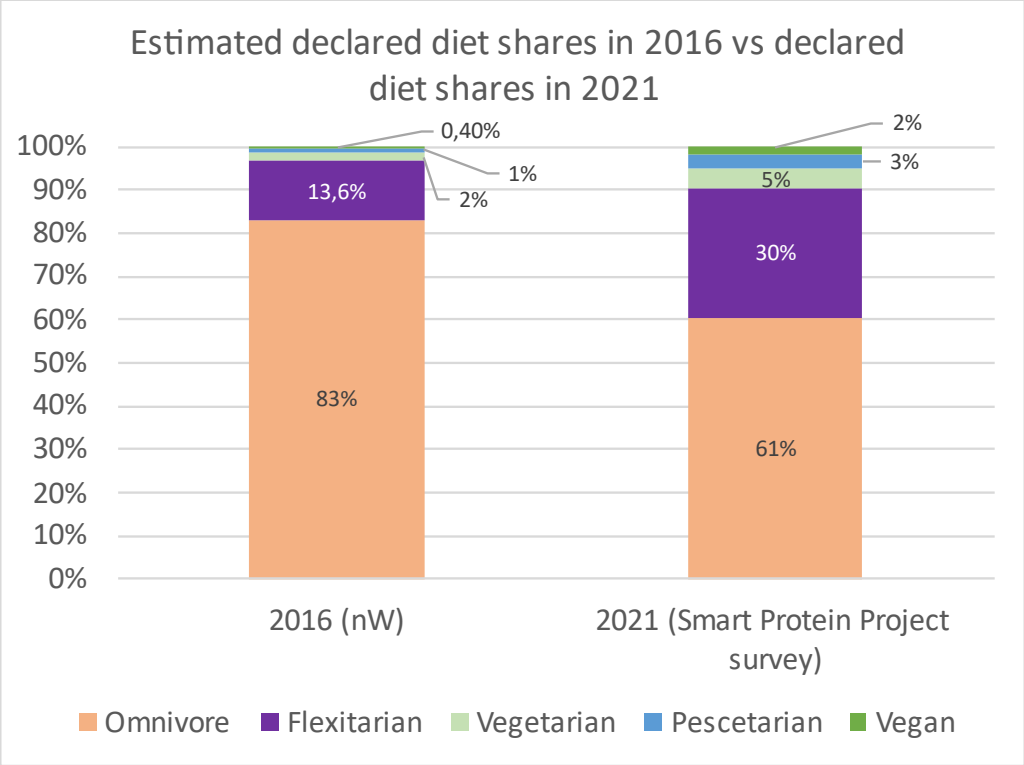

Figure 27: Estimated declared diet shares in 2016 versus declared diet shares from the Smart Protein Project survey (ProVeg International, 2021)

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Table 34: Shares of people in each diet type (rows) switching to the diet type in columns (example for DK, men, between 2021 and 2025).
Reading: in DK, 12% of men following the omnivore_170g diet will switch to the omnivore_100g_opt diet between 2021 and 2025

2021->2025	Omnivore_170g	Omnivore_75g	Flexitarian_30g	Pescetarian	Vegetarian	Vegan	Omnivore_100g_opt	Omnivore_45g_opt	Flexitarian_20g_opt	Pescetarian_opt	Vegetarian_opt	Vegan_opt
Omnivore_170g							12%					
Omnivore_75g								12%				
Flexitarian_30g									12%			
Pescetarian										12%		
Vegetarian											12%	
Vegan												12%
Omnivore_100g_opt								12%				
Omnivore_45g_opt									12%			
Flexitarian_20g_opt											12%	
Pescetarian_opt												
Vegetarian_opt												12%
Vegan_opt												

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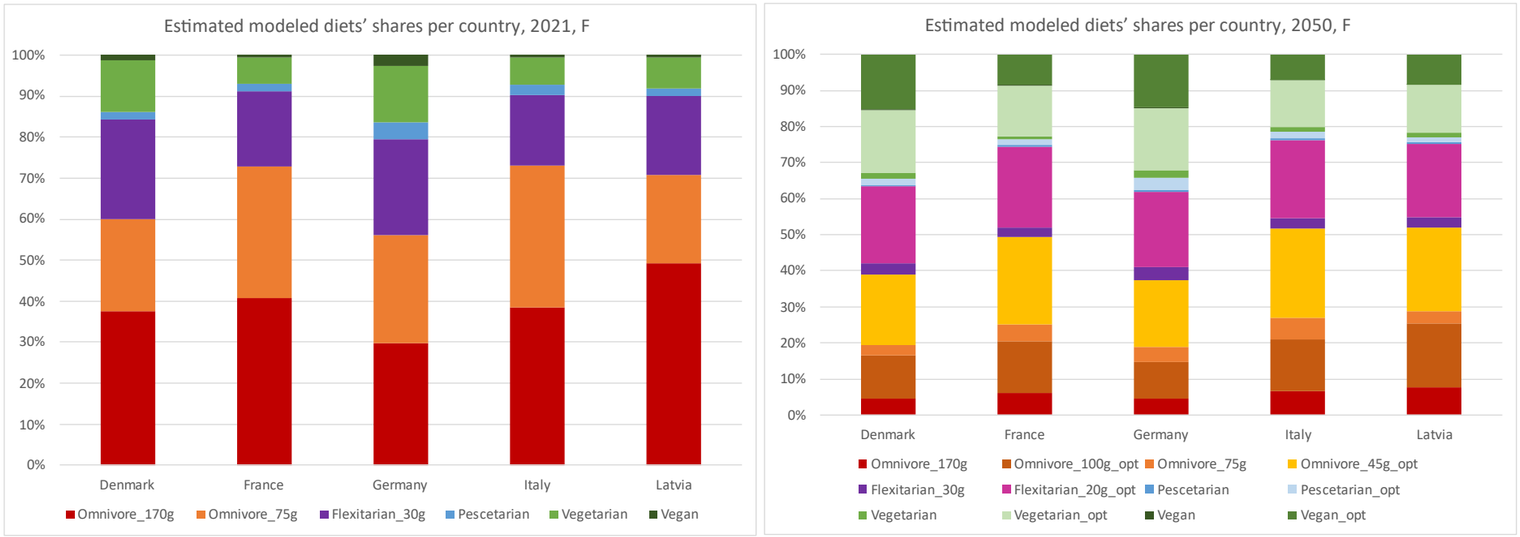

Figure 28: Diet type shares for women in the 5 countries studied

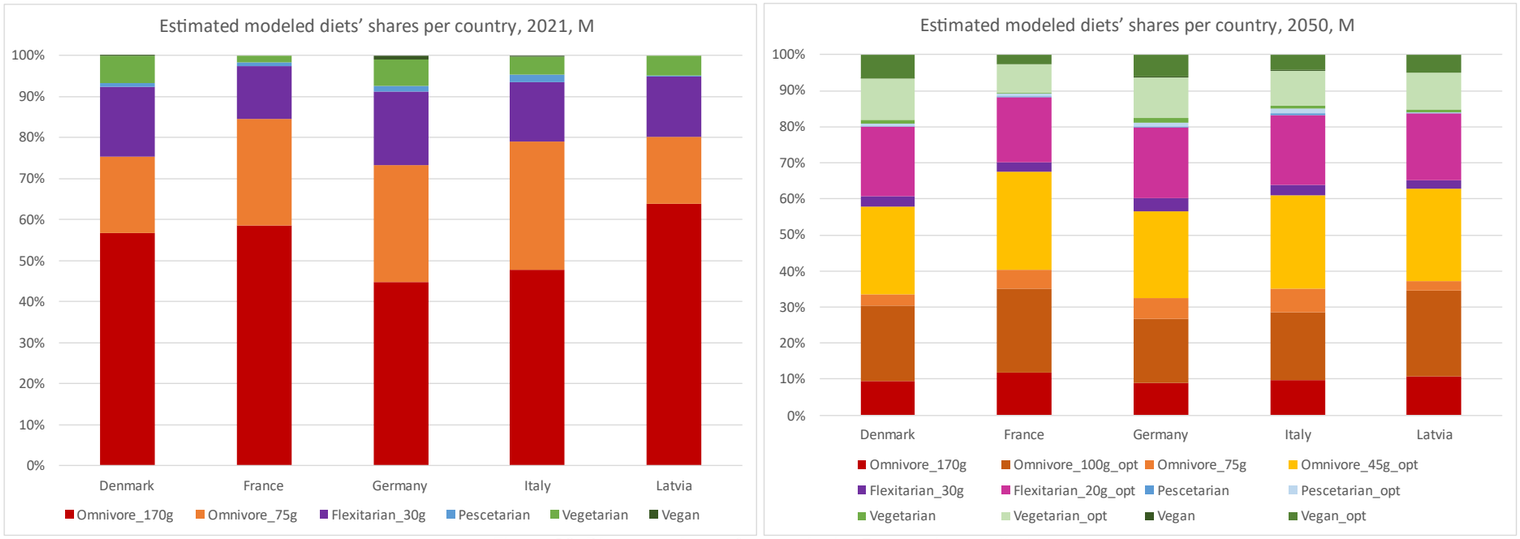

Figure 29: Diet type shares for men in the 5 countries studied

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Sharing space in housing

Policies

Table 35: Evaluation of the potential of policies according to existing barriers and levers for the "sharing space in housing" scenario assumption

Barrier/Enabler vs Policies	**Higher rent/taxes of bigger dwellings**	**Higher maintenance work and energy expenditure of bigger dwellings**	**Shared living is more reassuring**	**Anticipate ageing, fear of burden on family**	**Live closer to family**	**Community living**	**Higher rent of available housing**	**Unavailability of options in neighbourhood**	**Effort and cost of moving**	**Concerns about privacy loss**	**Concerns about impact on personal routines**	**Fear of conflicts**	**Attachment to current dwelling**	**No knowledge of alternatives**
Type	Enabler	Enabler	Enabler	Enabler	Enabler	Enabler	Barrier	Barrier	Barrier	Barrier	Barrier	Barrier	Barrier	Barrier
Financial incentives, living space advice, informational and practical support to move into a smaller or shared dwelling, with cap on m²/cap as a non-binding target		+	+	+		+			++	+/-	+/-	+/-		++
Support (inc. financially) shared housing projects (under conditions) through municipal living space agencies, with cap on m²/cap as a non-binding target							+	++						
Luxury tax for dwellings above a certain size	++													

Table 36: Evaluation of the qualitative potential of policies and their full-impact estimated date for the "sharing space in housing" scenario assumption

Policies	**Target Groups**	**Qualitative Potential**	**Full-impact estimated horizon**	**Comment**	**Modelled full-impact year**
Financial incentives, living space advice, informational and practical support to move into a smaller or shared dwelling, with cap on m²/p as a non-binding target	N/A	N/A	Medium/long-term	Response to financial incentives can be pretty quick, especially in times of power-purchase crisis for lots of households. However they should be progressively implemented according to alternatives' development. Shared options are currently scarce and will take time to develop. Cap on m²/p: politically sensitive.	2050
Support (inc. financially) shared housing projects (under conditions) through municipal living space agencies, with cap on m²/p as a non-binding target	N/A	N/A	Medium/long-term	Creation of municipal agencies can be quick, though reaching full impact can be foreseen at a medium/long-term	2050
Luxury tax for dwellings above a certain size	N/A	N/A	Long-term	Politically sensitive	2050

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Moderate car sizing

Policies

Policy note on the different contexts of car taxation (including weight) in several EU and non-EU countries

Germany

Germany is primarily concerned with industrial transition, and supports its manufacturers by subsidising the purchase of electric vehicles. Criteria such as vehicle weight or dimensions are therefore of little consideration at present.

The automotive industry is one of Germany's economic strengths[43]: depending on the year, the sector accounts for between 10 and 15% of its GDP. It is therefore logical that Germany should favour measures to increase demand for more environmentally-friendly vehicles, rather than measures to penalise consumers.

So, there are no specific measures on the weight of passenger cars in Germany. Instead, the country has opted for an incentive-based approach, introducing a substantial bonus to encourage the purchase of electric and hybrid vehicles. The German government's objective is to have a total of 15 million electric cars on German roads by 2030 (Les Echos, 2021). The German eco-bonus is therefore essentially a bonus for the purchase of electric and, to a lesser extent, hybrid vehicles.

That said, the eco-bonus has been reduced in 2023 (Le Point, 2021), in order to restrict it to vehicles that are *"more environmentally friendly"*, i.e. all-electric vehicles and those with a long range of more than 80 km (Ibid). The government intends to put an end to the subsidy for the purchase of electric vehicles from 2025 (Les Echos, 2021). However, penalties are still not on the agenda.

Denmark

Denmark is one of the few countries in Europe with no tax incentives for the purchase of vehicles, electric or otherwise (ACEA, 2022). This situation does not reflect a rejection of EVs by the authorities, but rather the importance of taxation in the Danish tax system. Denmark has the highest rate of compulsory taxation in the OECD, ahead of France[44]. As a result, vehicle taxation is also very high (KPMG, 2019).

Electric vehicles (EVs), however, benefit from discounts on certain taxes. These discounts are independent of criteria such as vehicle weight and dimensions.

Vehicle taxation, on the other hand, takes partial account of vehicle weight. Green taxation of the vehicle fleet breaks down as follows[45]:

- A weight tax applies to all vehicles registered in Denmark before 1997.
- For vehicles registered between 1997 and June 2021, households must pay a tax based on fuel consumption per km driven. The more fuel-efficient the vehicle, the lower the tax[46].
- For vehicles registered after 2021, a tax based on CO2 emissions will apply.

[43] https://www.insee.fr/fr/statistiques/4253389#graphique-figure1
[44] https://read.oecd-ilibrary.org/taxation/statistiques-des-recettes-publiques-2022_96463460-fr#page19
[45] https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/denmark/incentives-legislations
[46] https://www.iea.org/policies/3013-green-owner-tax

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In other words, while the Danish tax system does indeed have a kind of weight penalty, it should take less account of vehicle weight as time goes by and households renew their vehicles.

Spain

The automotive industry plays an important role in Spain: the sector accounts for around 11% of Spain's GDP, 9% of its jobs and 20% of its exports (Les Echos, 2020).

In other words, it is a vital sector for the Spanish economy, and the public authorities have historically been reluctant to regulate the sector. As a result, the country does not have any measures similar to the French car tax. Spanish vehicle taxation consists mainly of the following elements:

- Spain has a vehicle purchase tax based on the vehicle's CO_2 emissions. Vehicles emitting less than 120g of CO_2 per km driven are exempt from this tax[47].
- Every year, car owners have to pay the *Impuesto sobre Vehículos de Tracción Mecánica* (IVTM) to their local council[48]. This local tax is based on the horsepower of the engine. Each town is free to apply its own tax rate, within certain limits. They are unable, for example, to exempt electric vehicles from this annual tax, as this falls within the remit of the State. The largest cities (Barcelona, Madrid, etc...) offer a 75% discount for owners of electric vehicles (ACEA, 2022).

The Spanish tax system is therefore attractive for a number of reasons:

- There is little State involvement, apart from registration tax. This leads to major disparities between cities, which tax vehicle owners differently. To our knowledge, Spain is one of the few countries where vehicles are taxed mainly on engine power, and one of the few where the annual tax is not levied at national level.
- In any case, the withdrawal of the State makes it more difficult to encourage the purchase of electric vehicles, and to implement policies that discriminate between vehicles according to their weight. It is in fact impossible for a local authority to exempt EVs from taxation or to review the operating criteria of the IVTM.

Generally speaking, the Spanish tax model does little to promote EVs, regardless of weight considerations or vehicle efficiency. In its current form, the IVTM represents at best a lesser penalty for EV owners, and not really an eco-incentive (Alonso, 2020).

France

Following the Grenelle Environment Forum in 2007, France introduced an 'eco-tax' system, now known as the *"bonus-malus"* scheme. From the outset, this system focused on CO_2 emissions from cars. The choice of this criterion reflected the executive's desire to anticipate European legislation, which called for an average level of emissions from new vehicles of 130gCO2 per km by 2015. As a result, the bonus-malus scheme was structurally geared towards reducing CO_2 emissions from the outset, to the detriment of other criteria.

Initially, the bonus was awarded to vehicles emitting less than 120g of CO_2 per km driven, and the penalty was applied to new vehicles emitting more than 160g of CO_2per km.

The scale for this scheme has since been gradually strengthened, and the method of calculating the penalty has been enriched. In addition to CO_2emissions, a weight penalty now applies to vehicles weighing more than 1.8 tonnes.

As part of the draft finance act 2024, the government is expected to raise the threshold for triggering the penalty to 118g of CO_2per km, compared with 123g at present. The weight penalty should also be lowered to 1.6 tonnes. The government's intention is above all protectionist: the

[47] https://www.iea.org/policies/6766-registration-tax-based-on-co2-emissions
[48] https://www.dgt.es/nuestros-servicios/tu-vehiculo/tus-vehiculos/impuesto-de-circulacion-ivtm/

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threshold chosen allows foreign manufacturers to be targeted while sparing the models of most French manufacturers.

This economic objective of the reform of the malus is confirmed by the parallel revision of the methods for calculating the ecological bonus. The latter will now be calculated on the basis of an *"environmental score"*, which will take into account the life cycle of the car, and in particular the emissions linked to its manufacture. The government's stated aim is to give preference to cars *"made in Europe".*

Italy

Like Germany, Italy has historically been more in favour of policies to encourage the purchase of EVs (without weight or size criteria) rather than policies to tax polluting vehicles. The country introduced a car bonus in the early 2010s, but not a malus. One of the reasons for this is the dominance of the automotive industry in Italy, which follows a similar logic to Germany.

However, between 2019 and 2021, the EV purchase bonus was significantly increased, and a malus was introduced. This was a penalty based on CO_2emissions, with a fairly high trigger threshold, since vehicles were only affected if they emitted more than 161g of CO2 per km. The scale of this penalty ranged from €1,100 to €2,500 (above 290g of CO_2per km) (ACEA, 2022).

Latvia

Latvia's policies, including transport policy, can be explained by 2 main factors:

- The first is geopolitical: Latvia is a former member of the USSR and its policies are still strongly influenced by its links with Russia. Latvia has a direct border with Russia, and a quarter of its population is Russian-speaking. Economically, more than half of Latvia's oil and all its gas come from Russia[49]. Since the invasion of Ukraine in 2022, Latvia, like most of the former socialist republics, has taken a very firm line with Moscow (Les Echos, 2022).
- The second is economic. Latvia is in a complex economic situation: inflation will be 21% in July 2022 and the unemployment rate is 6.6%[50]. GDP per capita is also very low[51]. As a result, access to cars is not widespread: in 2006, more than a third of the Latvian population could not afford to buy a car. In 2018, 17% of Latvians are still in this situation[52].

As a result, Latvian policy is generally geared towards readjusting energy imports and rationalising public spending. Environmental issues are therefore secondary, particularly since 2022.

However, promoting EVs is relevant from a strategic point of view, since most of Latvia's energy production comes from hydroelectricity. What's more, Latvia has no energy resources of its own, and its oil imports come mainly from Russia[53].

Latvia has introduced a vehicle operation tax to promote the purchase of energy-efficient vehicles. It applies to all cars and must be paid annually. Until recently, the tax was based on the following parameters[54]:

- Engine capacity, in cm3.
- Engine power, in kW.

[49] https://www.diplomatie.gouv.fr/fr/dossiers-pays/lettonie/presentation-de-la-lettonie/
[50] Ibid.
[51] https://donnees.banquemondiale.org/indicateur/NY.GDP.PCAP.PP.CD?locations=FR-LV
[52] https://fr.statista.com/statistiques/590604/proportion-personnes-sans-moyens-automobile-lettonie/
[53] See footnote 49.
[54] https://www.fm.gov.lv/en/vehicle-operating-tax

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- The weight of the vehicle. Up to 1500 kilos, the penalty is €15 (€38 for vehicles registered before 2005). Above 3,500 kilos, the penalty is €110 (€274 for older vehicles).

This system was reformed in 2020: vehicles registered after 2008 are now subject to a tax based on CO_2emissions per km driven[55].

In other words, the Latvian tax system used to take vehicle weight and dimensions into account, but recent legislative changes have transformed the system into a simple CO_2penalty. In this respect, the Latvian example is very similar to that of Denmark.

Norway

Norway, like Germany, has introduced a policy that strongly encourages the use of electric cars. Electric cars benefit from a range of direct and indirect advantages, including exemption from VAT, free tolls and the possibility of using bus lanes (France Stratégie, 2018). These advantages are reinforced by the fact that electricity, mainly hydroelectric, is inexpensive for consumers (Ibid). For all these reasons, Norway is one of the few countries in the world where an electric vehicle costs the consumer less than a combustion vehicle.

Norway is also a very wealthy country: it has the 2nd highest GDP per capita in the world[56], and its population is concentrated in a few urban centres (notably Oslo and the surrounding area), which makes it easier for households to buy EVs and deploy the infrastructure needed for EVs to flourish.

This very generous tax incentive has been supplemented by a weight penalty on the purchase of an internal combustion vehicle. Above 1.4 tonnes, the vehicle is heavily taxed. Below this amount, purchase subsidies are provided (Meilhan, 2019).

However, the tax system is very unbalanced. The main consequence of this failure to combat the production and sale of heavy vehicles is that electric vehicles in Norway are being added to, rather than replaced by, the internal combustion vehicles owned by households (Guillouët & Mateus, 2023). This is because the weight penalty is payable on purchase, so households have an interest in acquiring an electric vehicle, but not necessarily in getting rid of their old internal combustion vehicle - on the contrary.

Since 2022, the government has been reviewing its strategy, in order to take greater account of certain environmental issues, but also because all the benefits granted to electric vehicles are expensive (around 4 billion dollars a year, Reuters, 2023). In particular, the idea is to start taxing electric vehicles according to their weight, and to reduce the tax exemptions previously granted to them, as the government believes that electric mobility is sufficiently established (Ibid).

- As a result, from 1 January 2023, all vehicles, including electric vehicles, will be subject to a new weight penalty. Above 500kg, each additional kilo will cost buyers NOK 12.5 (just over €1)[57].
- In addition, the VAT exemption for electric vehicles has been reviewed. From now on, above NOK 500,000 (around €42,000), VAT will apply as normal.
- Finally, the economic model for congestion charging, which is developing in most major urban centres, is changing to take better account of the externalities of road traffic. As a result, toll rates are being modulated according to various criteria, including the weight of vehicles, whether EVs or combustion-powered vehicles (DG Trésor, 2023).

[55] https://www.vvc.gov.lv/en/laws-and-regulations-republic-latvia-english/law-vehicle-operation-tax-and-company-car-tax-amendments-30112020?utm_source=https%3A%2F%2Fduckduckgo.com%2F
[56] https://www.tresor.economie.gouv.fr/Pays/NO/presentation-de-l-economie-norvegienne-1
[57] https://www.rtl.fr/actu/international/norvege-comment-les-vehicules-electriques-se-sont-imposes-sur-le-marche-7900220436

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Taken together, these reforms will drastically increase the price of electric vehicles, particularly the heaviest and most expensive.

This policy, which is relatively unprecedented in Europe, has been made possible by the already advanced development of EVs and the economic room for manoeuvre available to local residents, allowing policymakers to refocus mobility policies on more specific issues, such as the weight and size of the vehicle fleet.

As we said earlier, this highly advantageous tax system results in a shortfall of more than 4 billion dollars for the Norwegian government. The VAT exemption on electric vehicles alone cost around 1.3 billion dollars in 2021 for example (OECD, 2022a). This situation partly explains the end of the total VAT exemption mentioned above.

In addition to this reform, Norway is currently looking at ways of fundamentally reforming its tax system, since fuel taxes and other methods of taxing internal combustion vehicles are becoming less and less relevant, and revenues are steadily falling (Fridstrøm, 2019).

More specifically, the public authorities are considering introducing a tax on the use of electric vehicles. The authorities' reasoning is as follows: apart from CO_2 emissions, an electric vehicle generates the same externalities as a conventional vehicle (consumption of resources in its manufacture, contributing to the congestion and deterioration of the road network, etc). While fuel tax offsets these externalities for conventional internal combustion vehicles, there is no equivalent for electric vehicles (OECD, 2022b). The government is therefore *"thinking"* about a tax for EVs, based on a number of parameters, among others (Ibid).

The Netherlands

The Netherlands is one of the countries where EV sales are the highest in the world: by 2021, EVs will account for 25% of sales[58]. This boom has been made possible by a very generous policy of incentives: exemption from certain purchase taxes, subsidies of €3,700 for the purchase of a new vehicle, tax credits for private individuals and for operators of charging points, etc[59].

At the same time, the Netherlands has two environmental taxes that complement these incentives and explain the growth in EV use:

- The bpm[60], which is a purchase tax, is based on the vehicle's CO_2 emissions. Purchasers of an EV do not have to pay this tax.
- Motor vehicle tax (mrb)[61] is a tax based on vehicle ownership. It is payable every 3 months. It is calculated on the basis of 4 parameters: the type of vehicle, the fuel it uses, its environmental impact and its weight.

Iceland

Car owners in Iceland must pay a tax twice a year if they have a vehicle weighing more than 3.5 tonnes[62]. According to the official government website, this tax is based on the vehicle's weight and CO_2 emissions[63]. If the vehicle's CO_2 emissions are not known, then the tax is based entirely on the vehicle's weight. We can't say for certain whether EVs are subject to this tax, but if they are, the method of calculation would favour them, since CO_2 emissions are the main factor in the amount of the tax.

The Icelandic government recently suggested ways of starting to tax EVs. The success of its policy of promoting EVs has resulted in a fall in tax revenues, at a time when the government's

[58]https://www.tresor.economie.gouv.fr/Articles/2021/03/24/une-politique-fiscale-avantageuse-permet-l-essor-des-vehicules-electriques-aux-pays-bas
[59] Ibid.
[60] https://business.gov.nl/regulation/bpm/
[61] https://business.gov.nl/regulation/motor-vehicle-tax/
[62] https://island.is/en/vehicle-insurance-road-taxes
[63] https://www.skatturinn.is/einstaklingar/reiknivelar/reiknivel-bifreidagjalda/

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infrastructure spending is at an all-time high. Iceland is undertaking maintenance, modernisation and development work on its road network (Iceland Review, 2023).

Japan

The *Keijidosha* are small cars that have been sold in Japan since 1949.

The dimensions of these vehicles have evolved over time, and are now as follows: the maximum authorised length is 3.40m and the vehicles cannot be wider than 1.48m. Their height is conventionally around 2m. Their engine power must also be limited (eq. 64 hp). The weight of these vehicles is not fixed, but as a general rule they weigh less than 900 kilos, due to their modest size (Le Monde, 2023).

They now account for 40% of sales in Japan (Ibid). There are several reasons for this boom:

- Historic government support. The Japanese public authorities wanted to revive a car industry that was on the verge of collapse after the Second World War, and helped manufacturers to structure the sector. As a result, a favourable tax regime was put in place, and continues to exist. These vehicles benefit from a number of advantages: very low annual use tax/weight tax, reduced VAT rate on acquisition, more affordable roadworthiness tests and other procedures, lower motorway tolls.oA legislative and regulatory framework that intrinsically favours vehicle sufficiency and efficiency. For example, several energy-saving laws have been passed over the last 20 years, aimed at improving the efficiency of diesel and petrol vehicles. As a result, manufacturers of small vehicles such as *Keijidosha* have a considerable advantage over those forced to constantly revise their models.

While *Keijidosha* are helping to make the automotive sector more energy-efficient, there are a few points to note:

- This is a vehicle that, paradoxically, is struggling to develop in urban areas. Most users live in rural areas. It would seem that this is mainly due to economic reasons: as city-dwellers have more purchasing power, they are more inclined to buy less fuel-efficient vehicles.
- The maximum authorized dimensions of these vehicles have been steadily increasing since 1949. While they are still largely smaller and lighter than their European equivalents, the trend is quite pronounced.
- This type of model is found almost exclusively in Japan. The reason for this is that these cars are in no way intended for export (Challenges, 2019): various parts cannot be found outside the archipelago, the vehicles have been designed independently of Western construction standards, and so on. Importing the concept into Europe would therefore require the creation of a dedicated industry, which seems complex unless sufficiently strong tax incentives are put in place. However recent news could change the situation. The President of the European Automobile Manufacturers' Association, Luca de Meo, recently proposed replicating the Japanese model by adapting it to the European market.nThe idea would be to launch a new range of cars, somewhere between quadricycles (cars without a license) and small cars like the Twingo or Fiat 500 (Le Monde, 2023). According to de Meo, such vehicles would cost between €10,000 and €15,000, making them accessible to the general public.

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Table 37: Evaluation of the potential of policies according to existing barriers and levers for the "moderate car sizing" scenario assumption

Barriers/enablers vs policies	Existing EU/national regulations setting mandatory targets on greening of vehicles, with efficient impact on market and manufacturers' offer	Increasing pressure on material resources consumption and extraction	Social awareness on Climate change, increasing will to buy green products	Road safety as a political priority	Urban/ spatial planning constraints	Necessity for states and local authorities to find sustainable funding schemes for transport policies beyond CO_2 (in a 100% electric horizon)	high cost of EV - Necessity to make electric vehicles financially more accessible to support a just energy transition	Complexity of calculation and traceability	Influence of advertisement on vehicles	lobby of car industry (less profit on smaller cars, employment rates)	World trade rules/ free market	Policy prism on CO_2 emissions / policy resistance to change (focus on tailpipe emissions measures)	Lack of awareness on the impact of weight and size even for EV	social incentives to own a large vehicle: narratives on freedom, social status, and masculinity
Type	**Enabler**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Barrier**	**Barrier /Enabler**	**Barrier**	**Barrier**	**Barrier**	**Barrier**	**Barrier**
Include progressive targets of share of new A et B category vehicles sold on EU market for manufacturers	+++ Modification of EU market regulations: >Euro norms >regulation on CO_2 emissions for new cars and vans	+++	++	+ (*question whether this topic is out of EU competence?)	-	+	+++	+	+	+++	Complexity to adapt offer if the rest of the world market does not follow the same trend	+++	++	++
Include material consumption standards/caps for new vehicles sold on EU market, including electric vehicles.	+++ Modification of EU market regulations: >Euro norms >regulation on CO_2 emissions for new cars and vans	+++	+ (could be ++ since the setting of EU targets set a strong signal on what is considered green or not)			++	+++	++	+	+++	+	+	++	+
Shift to a life cycle analysis to measure CO_2 emissions and energy consumptions of vehicles sold on EU market	++ Modification of EU market regulations: >Euro norms >regulation on CO_2 emissions for new cars and vans	++	+++			++	+	+++	+	+++	++	++	+	
Include weight and size standards/caps in targets set for the greening of public and private vehicle fleets	+++ *UE : clean vehicle directive for public authorities; and forthcoming CE greening corporate fleets initiative* FR example: LOM and loi climat et resilience. The control on the rightful application of the targets need to be reinforced	+++	+	+		++			++	++	++	++	+	
Include weight and size and material consumption criterion in the calculation of car energy and emissions labelling	++ Modification of car labelling directive	+++	+++			++	+	++(for material)	++	++		++	+	+

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Barriers/enablers vs policies	Existing EU/national regulations setting mandatory targets on greening of vehicles, with efficient impact on market and manufacturers' offer	Increasing pressure on material resources consumption and extraction	Social awareness on Climate change, increasing will to buy green products	Road safety as a political priority	Urban/ spatial planning constraints	Necessity for states and local authorities to find sustainable funding schemes for transport policies beyond CO_2 (in a 100% electric horizon)	high cost of EV - Necessity to make electric vehicles financially more accessible to support a just energy transition	Complexity of calculation and traceability	Influence of advertisement on vehicles	lobby of car industry (less profit on smaller cars, employment rates)	World trade rules/ free market	Policy prism on CO_2 emissions / policy resistance to change (focus on tailpipe emissions measures)	Lack of awareness on the impact of weight and size even for EV	social incentives to own a large vehicle: narratives on freedom, social status, and masculinity
Type	**Enabler**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Barrier**	**Barrier /Enabler**	**Barrier**	**Barrier**	**Barrier**	**Barrier**	**Barrier**
Include weight and size criterion in fiscal schemes targeting physic and moral persons : >set increasing taxes on heavy and big new vehicles (exceptions planed for handicapped persons, big families and some professional uses) >set increasing bonuses on micro and (A/B) EV cars ***(*discussion needed on levels of incentives and targets to make them more accessible and fair)***	++ FR example: taxes on moral persons' vehicles (on CO_2 emissions and on atmospheric pollutants); bonus-malus; conversion bonus	++	++ (facilitate acceptability of taxation)	+	+	+++	+++		++	+++	+ (more about the world market approach of manufacturers than rules)	+ (but in FR the topic is growing in the political agenda)	+	++
Support the development of microcar industry in Europe to make EV accessible and relocate some of the production		+	+ (European production)				+++		+	++				++
National level: adapt motorway toll rates to size and weight of vehicles (existing in many country), by shifting J category vehicles (SUV/4x4/pick-up) to the same category than VUL and vans. ****Discussion needed on the impact of this measure (inequalities) because it targets vehicles bought on the second-hand market. Possible option: the higher fee applies to vehicles bought from 2025***	+++ FR: in France motorway toll rates already vary depending on the size, high, and weight of vehicles, but SUV and 4x4 are included in the lighter category (1). We suggest to shift J vehicles to category 2, to better reflect the costs of these vehicles on the degradation of the infrastructure.	-	+	++	+	+++	-	+	+	+++	-	++	++	+
Local level: adapt parking toll rates to size of vehicles. Apply a higher fee to SUVs (J category) ****Discussion needed on the impact of this measure (inequalities) because it targets vehicles bought on the second-hand market. Possible option: the higher fee applies to vehicles bought from 2025***	+ FR: Paris is considering this measure, but for now would only apply it to non-residential owners.	-	+ (but also problem of public support for this type of measure)	+++	+++	+++	+ (could have a reduced fee for smaller vehicles)	-	*	+++	-	+	+	+ (contestation)

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Barriers/enablers vs policies	Existing EU/national regulations setting mandatory targets on greening of vehicles, with efficient impact on market and manufacturers' offer	Increasing pressure on material resources consumption and extraction	Social awareness on Climate change, increasing will to buy green products	Road safety as a political priority	Urban/ spatial planning constraints	Necessity for states and local authorities to find sustainable funding schemes for transport policies beyond CO_2 (in a 100% electric horizon)	high cost of EV - Necessity to make electric vehicles financially more accessible to support a just energy transition	Complexity of calculation and traceability	Influence of advertisement on vehicles	lobby of car industry (less profit on smaller cars, employment rates)	World trade rules/ free market	Policy prism on CO_2 emissions / policy resistance to change (focus on tailpipe emissions measures)	Lack of awareness on the impact of weight and size even for EV	social incentives to own a large vehicle: narratives on freedom, social status, and masculinity
Type	**Enabler**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Enabler**	**Enabler**	**Enabler & Barrier**	**Barrier**	**Barrier /Enabler**	**Barrier**	**Barrier**	**Barrier**	**Barrier**	**Barrier**
Support the development of accessible car sharing practices in Europe, to adapt vehicles uses to the needs: >public local schemes to support access to electric fleets for low-income population looking for employment >fiscal incentive to rent personal vehicle on dedicated platform?		+	++		+		+++		+	++ (shift from individual property use)		+	+	++
Raise awareness on the impact of weight and height in the emissions of CO_2 and atmospheric pollutants, and in energy and material consumption	++ (set a strong signal for consumers)	++	++	++	++	++	++		++	+++		++	+	++
Build a new narrative on mobility: breaking narrative, values and misconceptions around cars to encourage other modes of transports and smaller affordable cars	++ (set a strong signal for consumers)	++	++	++	++	+	++		++	+++		++	+	+++

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Table 38: Evaluation of the qualitative potential of suggested policies and their full-impact estimated date for the "car sizing" scenario assumption

Policies	Target Groups	Qualitative Potential (nW evaluation)	Full-impact estimated horizon
Include progressive targets of share of new A et B category vehicles sold on EU market for manufacturers.	Manufacturers	A	mid term
Include material consumption standards/caps for new vehicles sold on EU market, including electric vehicles.	Manufacturers	A	mid to long term
Shift to a life cycle analysis to measure CO_2 emissions and energy consumptions of vehicles sold on EU market	Manufacturers	A on efficiency of the measure / B on the probability to be implemented	mid term
Include weight and size standards/caps in targets set for the greening of public and private vehicle fleets	public and private legal entities, and indirectly private individuals	A on efficiency of the measure / B on the probability to be implemented	mid term
Include weight and size and material consumption criterion in the calculation of car energy and emissions labelling	Manufacturers and buyers (entities and individuals)	B	mid term
Include weight and size criterion in fiscal schemes targeting physic and moral persons: set increasing taxes on heavy and big new vehicles (exceptions planned for handicapped persons, big families, and some professional uses); and set increasing bonuses on micro and (A/B) EV cars (discussion needed on levels of incentives and targets to make them more accessible and fairer)	Individual buyers and private entities	B	short term
Support the development of microcar industry in Europe to make EV accessible and relocate some of the production	Manufacturers and buyers (entities and individuals)	B	long term
National level: adapt motorway toll rates to size and weight of vehicles (existing in many country), by shifting J category vehicles (SUV/4x4/pick-up) to the same category than VUL and vans. (Discussion needed on the impact of this measure on inequalities because it targets vehicles bought on the second-hand market. Possible option: the higher fee applies to vehicles bought from 2025)	physic and moral persons - owners of vehicles / buyers	C	mid term
Local level: adapt parking toll rates to size of vehicles. Apply a higher fee to SUVs (J category) (Discussion needed on the impact of this measure on inequalities because it targets vehicles bought on the second-hand market. Possible option: the higher fee applies to vehicles bought from 2025)	moral and physic persons	C (strong impact in urban areas, more limited in rural areas)	short term in urban areas
Support the development of accessible car sharing practices in Europe, to adapt vehicles uses to the needs: public local schemes to support access to electric fleets for low-income population looking for employment, and fiscal incentive to rent personal vehicle on dedicated platform	Public authorities, private individuals, and private entities	B	mid term
Raise awareness on the impact of weight and hight in the emission of CO2 and atmospheric pollutants, and in energy and material consumption	private individuals and entities, policy makers	C	short term
Build a new narrative on mobility: breaking narrative, values, and misconceptions around cars to encourage other modes of transports and smaller affordable cars	private individuals and entities, policy makers	C	mid term

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Flying less

Policies

Table 39: Evaluation of the qualitative potential of policies and their full-impact estimated date for the "flying less" scenario assumption

Policies	Regulation level	Target group, perimeter	Qualitative potential	Full impact horizon estimated	Acceptability (political and societal)	Modelled full-impact year
Flight bans (where train alternative)	National, EU approval, EU for intra-EU	Airlines and passengers National, intra-EU and UK, CH, NO and neighbourhood Leisure and business	A	3h by 2025, 5h by 2030, 6,5h by 2035, 8h by 2040	Political acceptability is low, but societal acceptability medium-high at least until 3-5h. Hence delaying 8h to 2040, by when alternatives will have been developed (inc. night trains). Private flights should be banned to further increase acceptability.	Progressive impact
Frequent flyer levy	National, support by EU	Passengers (airlines indirectly) All flights and services concerned (extra-EU also)	B depending on level and progressiveness	Start 2025 and increase towards 2030 (to be able to use revenues asap for investments in alternatives)	Political acceptability is medium, societal acceptability high. Relatively high revenues possible and can be reinvested in rail infrastructure, services and support	2035
Increased tariffs on aviation (including ETS and VAT for kerosene)	EU for ETS National for VAT	Airlines, Airports	B depending on level	ETS: missing data VAT : by 2025	High	2035
Investment in rail infrastructure and services and increased public support for cheaper tickets	National, but EU funding and framing	Rail companies and network operators, rail passengers	B (no direct impact on aviation)	Long-term for infrastructure Short-medium for services and support. Can be funded in part by revenues from aviation levies and tariffs	High	2045
Banning airlines advertisement	National and local	Airlines	B	2025	Medium: strong push-back from companies – EU and MS should accompany this transition	2035
Banning airports extensions, capping airport capacities	National and local	Airports and Airport companies, neighbourhood impacts (less noise pollution etc)	B	Ban and cap from 2025	Medium (e.g. Schiphol lobby from the US)	2035
Sensitising, Information campaigns on impact of flying and problems with technological solutions	National, local (EU)	Citizens, media	C	Medium-term (2030-35)	Strong	2035
Increasing telework	National	Passengers and businesses for business flights	C	Medium-term (2030-35)	Medium-strong : some resistance from global companies possible	2035

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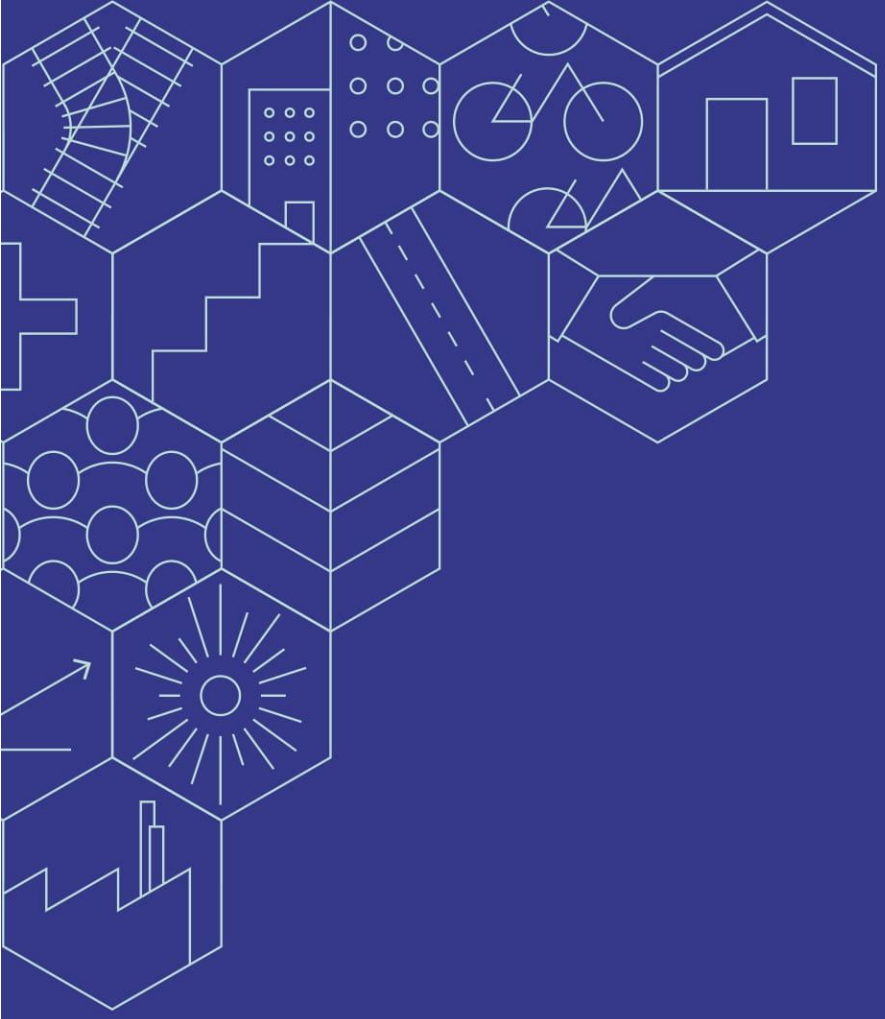

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