Lifestyle changes in mitigation pathways: policy and scientific insights

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Abstract
Lifestyle changes are key factors of the climate mitigation challenge because they drive the demand for energy, goods and food. They have received growing attention in the development and assessment of mitigation pathways, one of the key approaches used to inform mitigation policies. This paper contributes to this emerging literature by examining the political and scientific implications of integrating lifestyle changes into mitigation pathways. We analyse a large sample of pathways, supplemented by interviews with practitioners, to provide a perspective relevant to both scenario production practices themselves and the science-policy process in which they are included. We use three illustrative pathways to describe what it means to explore lifestyle changes and how this exploration can be conducted (indicators, dimensions, precision). We summarize the observed benefits of the explorations of lifestyle changes in scenario production by considering three main contributions of scenarios to policy decision-making: explicit knowledge, mediation tools and framing power. We also discuss why the integration of lifestyle changes poses a potential challenge to the robustness and reliability of pathway production methodologies, which is a condition for their policy-relevance. We therefore argue that the implications of this integration need to be carefully characterized in order to maximize the policy relevance of the analysis without compromising the robustness of the scenario development and assessment process. The nature of lifestyles, which reflect values and preferences and require a multidisciplinary approach, raises significant policy neutrality challenges and scientific challenges. Overcoming these challenges can lead to more policy-relevant pathways: we describe existing approaches in the literature and analyse their contributions and limitations.

1. Introduction
Recent years have seen a growing interest for lifestyle changes within the framework of decarbonisation pathways (van Sluisveld et al 2016, van den Berg et al 2019). This can be seen as a part of the renewed effort to highlight demand side issues in these approaches (Creutzig et al 2018, Mundaca et al 2019), in light of the widening gap between the limited progress made on emissions reductions in the past 30 years and increasingly ambitious mitigation targets (IPCC 2018). The existence of rebound effects that negate efficiency gains (Sorrell et al 2009), and uncertainties about sequestration technologies (Anderson and Peters 2016, Beck and Mahony 2018) also led to an increased focus on lifestyle-oriented options: e.g. dietary transition, demotorization, reduced consumption of goods (Bertram et al 2018, Grubler et al 2018, van Vuuren et al 2018). Grubler et al (2018) note that significant reductions in energy demand through rational uses (which are driven by lifestyles) and efficiency can create ‘the necessary space for a feasible supply-side decarbonisation within a 1.5°C emission budget without the need for negative
1 Which does not mean without negative emissions since, as stated in the Summary for Policymakers of the 1.5 °C IPCC Special Report: ‘Significant near-term emissions reductions and measures to lower energy and land demand can limit Carbon Dioxide Removal deployment to a few hundred GtCO2 without reliance on bioenergy with carbon capture (C3).’ See https://archive.ipcc.ch/pdf/special-reports/sr15/sr15_spm_final.pdf and supplementary information (available online at stacks.iop.org/ERL/16/015005/mmedia) https://doi.org/10.1088/0266-5611/16/015005/mmedia}

emission technologies\(^1\) (Grubler et al 2018). Akenji et al (2019) emphasise the role of lifestyle changes for the 1.5 °C target, and conducts a consumption-based accounting assessment of lifestyles changes scenarios.

1.1. A fundamental concept but hard to tame in scenarios

The concept of lifestyles is particularly suitable when addressing demand-side issues. From an analytical point of view, this concept makes it possible to capture the full range of individual behaviours that compose ‘activity levels’ and to distinguish them from the behaviours that affect carbon intensity (e.g. choice of energy-efficient or low-carbon technologies). It thus corresponds to the ‘avoid’ and ‘shift’ levers distinguished by Creutzig et al (2018). More broadly, the concept of lifestyles establishes the link between what gives meaning and ‘shape’ to our lives and the resources we use. By relating to our ways of doing, having, using and displaying (Ropke 2009), it makes explicit the ultimate reasons for greenhouse gas emissions (e.g. food, clothing, housing, socialisation). Consequently, lifestyle changes can have a significant effect on one’s carbon footprint (Druckman and Jackson 2009, Heinonen et al 2013). It is therefore not surprising that lifestyle changes are regularly cited among the options that could help meet the mitigation targets (IPCC 2018).

However, this concept is hard to tame because of its complexity: lifestyles can be analysed at multiple geographical and social levels; they are dependant of psychological, demographic and economic variables; they are a nexus between the social life and the techno-sphere. Moreover, the role of lifestyle changes in climate mitigation is not straightforward. Lifestyle changes are far from being a consensual way to pose ‘activity levels’ and to distinguish them from the techno-sphere. Another illustration of this framing power of the concept of lifestyles is given by Beck and Mahony (2018) who explore recent controversies over negative emissions technologies and underline the fact that IPCC works have a ‘world-making power by providing new, politically powerful visions of actionable futures’. They suggest that more reflection should be given to the political role of scientific assessment, and it can be deduced from this work that a reflection of this kind would also be useful for an equally controversial subject such as lifestyles.

1 More broadly, we can distinguish at least three types of contribution of scenarios to policy making. The first one is quite straightforward: this is the explicit knowledge (e.g. emissions curves, potential of measures, costs of implementation, timeline) that are the concrete outputs of pathways. This is a common way to consider scenarios in the climate community. The second one is also common: scenarios are supports that ‘enable constructive dialogue amongst stakeholders’ (Waisman et al 2019), they have a contribution in terms of mediation.

The third contribution, less obvious, is underlined by science and technology studies (STS) scholars (Garb et al 2008, Beck and Mahony 2018, Cointe et al 2019): ‘the influence of scenarios is not simply through changes in explicit knowledge and understanding, but also through more implicit shifts in how problems are framed’ (Garb et al 2008). This encourages us to consider that the way problems and solutions are chosen and represented are also a key output of scenario for the policy debate. Thus, models may not be only mapmakers—i.e. producer of explicit knowledge. Haikola et al (2019) show that, because of the issue of uncertainties, the complexity of modelling, the need to overcome black box effects, and the fact that modellers’ choices are also normative (Ellenbeck and Lilliestam 2019), (see also Cointe et al (2019) on IAMs community as an epistemic community), we could consider that integrated assessment modellers not only produce explicit knowledge, but also frame problems and solutions, which relativises the boundary between the scientific and political spheres. Another illustration of this framing power of scenarios is given by Beck and Mahony (2018) who explore recent controversies over negative emissions technologies and underline the fact that IPCC works have a ‘world-making power by providing new, politically powerful visions of actionable futures’. They suggest that more reflection should be given to the political role of scientific assessment, and it can be deduced from this work that a reflection of this kind would also be useful for an equally controversial subject such as lifestyles.

Building on these perspectives, this paper aims to contribute to a better understanding of the political and scientific implications of the integration of lifestyle changes in mitigation pathways designed to inform decision-making. Specifically, we want to
understand under what conditions a better representation of lifestyles in pathways could help decision makers to improve the consideration of lifestyle changes in their strategies and climate policies. We are interested both in scenario production practices themselves (including but not limited to modelling) and in the science-policy process in which they are included.

2. Methods

The core of our approach consisted in analysing a large set of scenarios developed in different science-policy contexts, with a focus not only to the scenario itself but also to the process in which it is embedded. We supplemented our scenario analysis with 16 interviews with practitioners involved in the scenario making process (see list, methodology and summaries in Annex 2).

We consider a sample of $N = 75$ scenario development initiatives. The scope of our subject encompasses both academic and non-academic materials, making any systematic review based on academic databases incomplete at best. In order to include as many relevant pathways as possible, we built our sample primarily from previous case studies and reviews dedicated to related issues (Le Gallic et al 2015, 2017, Samadi et al 2017, The Shift Project 2019, van den Berg et al 2019, Saujot and Waisman 2020). By design, our sample contains both pathways that considered lifestyle changes (in order to identify innovative practices), alongside others that reflect the diversity of authors and contexts in which mitigation pathways are developed without any criteria for taking lifestyle changes into account. This second type includes government exercises, pathways developed by academic modelling teams (a number of which are notably part of the sets of global pathways described in the recent IPCC reports), pathways developed by non-governmental organizations, multinational energy companies (BP, Shell, Equinor) or international organizations (International Energy Agency, World Energy Council, International Renewable Energy Agency). This second set of pathways therefore aims at understanding current practices, more through an overview of their diversity than by establishing comprehensive statistics. The full list of corresponding references is available in Annex 1.

Based on this set of scenarios we developed a framework to understand the implications of the integration of lifestyles in our cases. This includes three main components: (a) a factual component (‘What does it mean “to explore lifestyle changes” in this study? What, if any, are the changes in lifestyles considered and how are they described?’), (b) a methodological component, in which we paid particular attention to models (‘How have lifestyle changes been explored?’) and, (c) an output component (‘Why explore lifestyle changes in this context? What difference does it make to the science-policy process?’).

Since the analysis covers heterogeneous and very rich material, we adopted an illustrative approach to deliver a first description of the factual and methodological components in the result section. We use three cases to illustrate the essentials of what it means to explore lifestyle changes (section 3.1) and of the methodological practices at work (section 3.2). We provide a more comprehensive overview in Annex 1 through a standardized summary of the analysis of the 75 cases. We selected our three illustrative cases by considering elements of complementarity and representativeness (see also Annex 3 for more details). They are referenced below as European Climate Foundation (2018), French Ministry of Ecology (2018) and Grubler et al (2018).

3. Results

NB: we use (*) in this section to clearly identify articles that are part of our sample.

3.1. What does it mean ‘to explore lifestyle changes?’

Common practice generally consists in identifying changes in mobility, consumption, and/or housing practices, which may or may not be explicitly referred to as ‘lifestyle changes’; and formulating assumptions that allow for the quantification of their effects on the ‘system’ (e.g. the economy, the energy system). This quantification generally applies to ‘activity level’ indicators.

Table 1 provides an overview of the portfolios of lifestyle change assumptions considered in the three illustrative studies. In the global North, exploring lifestyle changes most often involves considering lower activity levels. In the global South, the first driver of change is the increase in living standards, i.e. higher levels of consumption, larger housing units, and higher and faster mobility. However, exploring lifestyle changes in the global South can also include descriptions of alternative pathways from those in the global North that are, for example, less car dependent (Grubler et al 2018*), or less intensive in industrial goods (Méjean et al 2019*).

Although the lifestyle changes described in table 1 cover almost all of the changes that are currently considered in mitigation pathways, we also identified a few other changes, characterizing a richer representation of the concept of lifestyles. These include an explicit consideration of changes in values (e.g. challenges to relationship to space, to speed or consumerism in Prime Minister’s Office (2009)* or Theys and Vidalenc (2013)*); changes in cohabitation practices (Millot et al 2018*, Vita et al 2019*); changes in time-use patterns (Weber and Perrels 2000*, Anable et al 2012*).
Table 1. Lifestyle changes (through changes in practices), indicators used to consider these changes, and effect of the changes on the indicator value for the three illustrative cases.

| Changes in lifestyles | Common indicators used to quantify the effects | Grubler et al (2018) | European Climate Foundation (2018) | French Ministry of Ecology (2018) |
|-----------------------|-----------------------------------------------|----------------------|------------------------------------|----------------------------------|
| **Consumption practices** (e.g. food, goods) | Further accumulation of consumer goods and devices | Consumption of industrial goods, number of devices owned | ↑ (moderate) | ↑ |
|                       | Changes in consumer behaviour leading to lower product demand | Calorific intake & share of (red) meat | ↑ |
|                       | Increase in living standards | Calorific intake | → (stabilisation) | → (cap) | ↓ |
|                       | Growing concerns for healthy living and dietary shifts | Share of (red) meat | ↓ (moderate) | ↓ (moderate) | ↓ |
|                       |                               | Calorific intake | ↑ (moderate) | ↑ |
| **Mobility practices** | Increase in living standards | Passenger kilometres (total) | ↑ (moderate) | ↑ |
|                       | Partial substitution of physical mobility by telepresence | Kilometres passengers (total) | ↓ (moderate) | ↓ (moderate) | ↓ (moderate) |
|                       | Shift towards shorter trips accompanied by urban policies | Kilometres passengers (total) | ↓ |
|                       | Substitution of private cars by shared or active modes | Share of car mode | ↓ | ↓ |
|                       | Shared transportation | Kilometres passengers by plane | ↑ | ↑ | ↑ | ↑ |
|                       | Preferences for urban and dense areas | Residential floor area | ↓ (moderate) | ↓ |
|                       | Reverse preferences for distant holidays | Residential floor area | ↑ (moderate) | ↑ (stabilisation) | ↓ |
| **Housing practices** | Increase in living standards | Base temperature for thermal comfort | ↓ |
|                       | Preferences for urban and dense areas | Residential floor area | ↓ (moderate) | ↓ |
|                       | Saturation of preferences for larger dwelling | Residential floor area | → (stabilisation) | ↓ |
|                       | Change in comfort standards | Residential floor area | ↓ |

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3.2. How have lifestyle changes been explored?
As already suggested (e.g. by Kriegler et al 2018, van den Berg et al 2019), lifestyle changes and—more broadly—demand-side aspects have historically received less attention from modellers than supply-side aspects. Nonetheless, we have identified a significant number of cases that include approaches aiming to represent lifestyle changes in mitigation pathways. The methodologies implemented in the exercises we analysed generally combine qualitative and quantitative approaches (most often modelling). We observe a multitude of combinations that describe a continuum between approaches centred on the construction of narratives (by modellers alone or as part of participatory approaches) that are subject to a posteriori quantification; and approaches centred on modelling, where the structure of the model(s) guides the construction of pathways. Our three illustrative cases described below provides examples of such combinations.

Grubler et al (2018)* introduced lifestyle changes into an Integrated Assessment Model (IAM) (MESSAGE-GLOBIOM framework, including inter-temporal optimization solution framework) by exogenously adjusting the ‘activity levels’ (which are inputs into the modelling process) by justifying these assumptions through a separate, narrative-driven, qualitative exercise involving experts. These activity levels are measured through indicators including passenger-kilometres by mode, floor area of residential buildings, the number of devices or the calorific intake of food (see also table 1). The exercise led by the European Climate Foundation (2018)* was supported by a simulation model without optimisation (also classified by the authors as a ‘directed graphs model’). The lifestyle changes are described as a range of levers (e.g. the proportion of people travelling by car) associated with several effort ambitions. These have been defined through expert workshops and made transparent to the users of the model. The modelling framework used to build the scenario of the French Ministry of Ecology (2018)* is, by contrast, composed of several sectoral techno-economic models, whose results are then aggregated and assessed by other models. The sectoral models include some parameters used to represent the effects of lifestyle changes (e.g. occupancy rate of transport modes), which have been identified through a previous reflection process.

These cases illustrate the fact that, contrary to technological changes that are often driven by endogenous dynamics (often based on economical rationale), changes in lifestyles are most often thought out as part of a qualitative exercise. They then go through an interpretation exercise in order to translate the resulting qualitative assumptions into quantitative assumptions to be into the models. The main degrees of variability are the way in which the process of defining hypotheses and the modalities of quantification are carried out. And we argue that these methodological choices matter for the science-policy process, as we will discuss in section 4.

3.3. What difference does it make to explore lifestyle changes?
In this section we summarize the observed contributions of the explorations of lifestyle changes in the mitigation pathways under study. We present these contributions as potential benefits to the science-policy process following the three main roles of pathways that we identified in introduction.

3.3.1. Production of knowledge
This is the most obvious and frequent contribution in our sample. As pathways are used to inform decision-makers, we identified at least two types of information. First the quantification of the contribution of lifestyle changes to the climate mitigation effort, van Sluisveld et al (2016)* provides an example of a worldwide specific quantification using an IAM (IMAGE, lifestyle changes are represented through changes in some parameters), which is later put into perspective with other types of changes for the assessment of 1.5 °C scenarios (van Vuuren et al 2018*). Vita et al (2019)* provides a refined analysis thanks to a multi-regional input–output (MRIO) framework that has a superior ability to study changes in consumption patterns. It allows them to quantify separately the effects of a particularly wide set of lifestyle changes (e.g. local clothing; sharing and repairing practices, see also Annex 1). Whereas this kind of quantifications are rare for developing countries, Grottera et al (2020)* quantify different scenarios of lifestyle change in mitigation pathways through a computable general equilibrium (CGE) model grounded on an input-output framework for Brazil, allowing the exploration of systemic effects (on prices, incomes and growth). In a very recent study Millward-Hopkins et al (2020)* also developed an bottom up approach starting from the different components of lives (e.g. housing, food and mobility practices) to inform about the minimum energy needed to provide decent living with a global perspective in 2050.

Second, some of the pathways of our study provide another type of output by preparing decision-makers for the uncertainties of future lifestyles. These pathways, built on an exploratory approach (rather than a normative one), also include an exploration of lifestyle changes that are not necessary driven by sustainability. The five pathways described in Emelianoff et al (2013) are probably the most contrasted ones we observed (e.g. they include a society based on human enhancement technologies, another where 40% of the population live in sufficiency-oriented communities). These pathways were developed mainly through an interdisciplinary qualitative approach and
quantified *a posteriori* at the household level through a carbon footprint approach. The pathways described in Millot *et al.* (2018)*∗* and Fraunhofer Institute for Systems and Innovation Research ISI (2019)*∗* provide some other examples of such exploratory pathways, but with national or regional quantifications.

### 3.3.2. Mediation

As previously noted, pathways are used as a medium to support participatory approaches with citizens or stakeholders (see an example in Fortes *et al.* (2015); and an analysis in Elsavah *et al.* (2020)) and to disseminate and communicate scenario results in order to enable different communities (e.g. scientists) to dialogue and work together (Waisman *et al.* 2019). This is enabled as futures can be considered as ‘boundary objects’, as described by Star and Griesemer (1989) and Granjou and Mauz (2011). We identified several examples of such approaches.

One of the most notable is the exercise led by the Finnish Prime Minister’s Office (2009)*∗*, where an ambitious participatory approach was implemented to establish the mitigation strategy (including in particularly numerous stakeholder and expert workshops and in *a posteriori* consultation of citizens). Several lifestyle changes were considered in the four mitigation pathways. This exercise led to identify measures to encourage lifestyle changes (related to dietary shift, modal choice, and household location in particular). The MRIO modelling of Vita *et al.* (2019)*∗* are also derived from outputs of workshops where European citizens and other stakeholders produced their visions of sustainable lifestyles.

Another observed practice is the development of concrete narratives of life in 2050, consisting in describing future individual or household lifestyles in order to ‘root’ the low-carbon transition into everyday life. These characterizations take the form of household portraits—i.e. descriptions of daily life (see ADEME and WeDemain 2015, Elioth 2017)*∗*, EPE 2019)*∗*. This helps us imagine the practical realities of life in a low-carbon world and share the challenges of the transition with citizens.

### 3.3.3. ‘Framing’ the possible transitions

As argued e.g. by Beck and Mahony (2018), pathways play a role in framing the worldview associated with the necessary transition to achieve ambitious mitigation goals. These assessment exercises furnish ‘policy-makers with the objects, variables and relations upon which they seek to exert influence’ (Beck and Mahony 2018). Here we ask: to what extent do existing pathways contribute to placing lifestyle changes within the landscape of existing mitigation options (for policy-makers)?

We voluntarily included in our sample several pathways that are frequently referred to in scientific and political discussions on climate mitigation and energy futures. These include several of the International Energy Agency (IEA)’s pathways, several quantifications of the five shared socioeconomic pathways (Calvin *et al.* 2017)*∗*, Fujimori *et al.* 2017)*∗*, Fricko *et al.* 2017)*∗*, Kriegler *et al.* 2017)*∗*, van Vuuren *et al.* 2017)*∗*), as well as prominent foresight studies from multinational oil and gas companies, and sets of pathways assessed within the IPCC’s Special Report 1.5 °C. Our analysis shows that these pathways consider only a few lifestyle changes. Except for changes related to modal choice in mobility and, to a lesser extent, dietary shifts in several recent studies using IAMs, other lifestyle changes are rarely considered in these pathways, even if we can mention some recent—but still partial—efforts (Bertram *et al.* 2018)*∗*, Grubler *et al.* 2018)*∗*, Liu *et al.* 2018)*∗*, van Vuuren *et al.* 2018)*∗*). Changes in consumption patterns (e.g. durable goods, services), in cohabitation practices, in tourism and travel practices, in sharing practices, in household location or in relationship to space (e.g. virtual mobility or the size of the activity space) are for example rarely explicitly considered in this set of pathways.

Except for Prime Minister’s Office (2009)*∗*, the same observation can be made for the pathways that are the most integrated into political processes in our sample (e.g. DGEMP 2005)*∗*, DGEC 2008)*∗*, UK Government 2017)*∗*, European Commission 2018)*∗*, French Ministry of Ecology 2018)*∗*).

Among the other studies of our sample (that are more academic-oriented), we identified a significant amount of pathways that considered various lifestyle changes. Yet, considering the non-systematic and scattered character of this literature, combined with its academic orientation, raises the question of under which conditions these studies can have a significant power to frame worldviews.

This results led us to consider that this participates in a specific and potentially incomplete framing of the issue, leaving aside the possibility of lifestyle changes as a solution. These conventional modelling approaches generally fall short of capturing the lessons from the literature that demonstrates that demand is actually the result of an interaction between society and technical systems (Shove 2004, 2010, Geels *et al.* 2017).

### 4. Discussion

The next generation of mitigation pathways has an important role to play in informing future decarbonisation policies. Our analysis improves the understanding of how lifestyle changes are considered in existing pathways and we argue that it is crucial to encourage better practices in order to enrich the mitigation effort. Based on our review of existing practices and further literature, we discuss here the challenges and opportunities for better practices.
4.1. Challenges facing more and better consideration of lifestyle changes in mitigation pathways

The integration of lifestyles may pose a potential challenge to the solidity and reliability of pathway production methodologies, which is a condition for their policy-relevance. As we will see, this challenges both the production of knowledge, mediation and framing functions of pathways, which can hinder the full consideration of lifestyle changes in mitigation pathways.

4.1.1. Challenges due to the political nature of lifestyle changes

The political nature of lifestyle changes is probably one of the main reasons explaining why lifestyle changes are not considered in some prominent or governmental mitigation pathways. The cautious way in which lifestyles have been explored in the French Ministry of Ecology’s exercise gives a practical illustration of the sensitivity of this issue (as reported by their authors). For example, the study was careful in its communication to avoid any expression that might suggest a trade-off in terms of comfort or affluence loss, and also considered an intensity and a scope of lifestyle changes restricted to the most consensual practices and changes (e.g. carpooling, modest dietary shift). Another illustration can be seen in the objections to the assessment of potentials associated with lifestyle changes identified by Dufournet et al (2019).

Lifestyles are a set of both practices and representations, which include values, cultural, and social factors. Considering their change therefore potentially implies transforming the balance of values and preferences in a given way, which is not necessarily consensual. Assumptions of change may also be perceived as undermining the individual freedom to compose one’s lifestyle, whereas liberty is generally considered a pillar of the Western liberal democracies. This perception ignores, however, the fact that there are already a wide array of social, urban (Gudipudi et al 2019), country/regional (Ivanova et al 2017) or institutional (Munck Af Rosenschöld et al 2014) constraints and inertia that explain the extent in which individuals are limited in their agency to opt for low-carbon lifestyles. Considering the policy decisions that influence the course of changing lifestyles is therefore far from neutral. This aspect is all the more crucial given that scenarios, like the ones gathered by the IPCC in their report, have performative power, i.e. they can transform ‘purely speculative visions into politically powerful visions of actionable futures’ (Beck and Mahony 2018).

Moreover, some lifestyle changes are connected to more global debates on economic growth and changes in consumption patterns (e.g. less material consumption, more shared goods, less travel by plane), and these debates are key determinant of political and social acceptance (Akenji 2014, Wiedmann et al 2020). Lifestyle changes are also connected to development paths (e.g. urbanization, motorization), which can lead to difficult political debates. For example, there is an apparent contradiction between the promotion of dense urban areas to enable sustainable mobility (e.g. Creutzig et al 2016, de Coninck et al 2018) and the persistence of aspirations for individual housing (see e.g. the international survey described in Descarrega and Moati 2016). Lifestyles, as a holistic concept, cannot be reduced in scenarios to the representation of independent consumption choices without losing its political meaning, which is precisely what needs to be discussed so that it can be integrated into action strategies. Thus, it challenges both the mediation role of scenarios and the production of robust knowledge on the potential of lifestyles changes (implementation feasibility).

4.1.2. Quantification challenges

The global and qualitative reflection process that fixed overall lifestyle hypotheses had to go through an interpretation exercise in order to translate the resulting qualitative assumptions into quantitative assumptions that could be fed into the models. At a macro level, O’Neill et al (2017)’s work has been an important first step in providing qualitative narratives for mitigation pathways modelling. Despite methodological efforts, this approach necessarily involves the reductive prism of modelling tools: the analysis of lifestyles must be done within a predetermined framework that is fairly constrained by the modelling structures, which were not initially conceived to accommodate lifestyle changes. We identified several limits, in particular: some indicators are too aggregated (e.g. final energy/capita, annual passenger-kilometres/capita); some sectors are frequently not included in the modelling scope (e.g. aviation, food); the most-common GHG accounting approach (territorial-based) is not satisfactory to consider changes in consumption patterns; certain assumptions will be precisely described, while others will remain partially or completely implicit. This is of particular importance when pathway development includes a participation process: an inadequate modelling framework can be prejudicial to the consideration of lifestyle changes in collective discussions. In addition, by analysing the methodological challenges of connecting qualitative and quantitative analysis in scenario building processes, Elsawah et al (2020) identify in their recent review other sources of tension and challenges: how to conserve consistency and scientific credibility? Which output (storyline or modelled scenario) is the final benchmark of the study? These methodological difficulties give rise to a several experimentation and approaches, as we will see in the next section.
4.1.3. … among broader scientific and methodological challenges

None of the pathways in our broader sample satisfactorily investigated the policies that may influence future lifestyles, their cost-effectiveness, their consequences on well-being, and, ultimately, their legitimacy. The case of Grubler et al (2018) is representative in this respect. The assessment shows the benefits of following a low-demand pathway with, in particular, a moderate increase in activity levels (at least in the global North), but no science-based policy advice on how to achieve this or analysis on the potential implications, for example, in terms of well-being. In other words, relying on a set of simplified assumptions is useful to get an order of magnitude of the impact in terms of emissions, but says little about the conditions of implementation and may not be sufficient to serve as a basis for discussion among stakeholders. By extension, it may lead to the consideration of lifestyle changes as zero cost options (Bertram et al 2018). This is a limitation to producing policy relevant pathways, which should provide lessons in terms of means of implementation.

However, the human and social sciences have a lot to say about understanding changes in lifestyles: drivers (e.g. household life-cycle, values), constraints (e.g. infrastructure lock-in, social norms), and the dynamics at play (e.g. rhythms, sequences). This knowledge has been applied to mitigation issues bringing out several active research fields, e.g. sustainable consumption, sustainable mobility.

Yet, as an extension of the quantification challenge, there is a broader challenge related to the integration of social science knowledge in quantitative foresight exercises, because of epistemic differences (Geels et al 2016, Elsawah et al 2020). The different dimensions of lifestyles and their associated dynamics are hardly understood by rational choice theory, which dominates the techno-economic models analysed by Rosenbloom (2017). In a field historically dominated by economists, engineers and modellers, most of the most visible pathways are based on the same epistemic approach, in particular concerning agents (e.g. access to information, rational choice, fixed preferences) and the role of market prices. They also share a positivist approach that seeks to identify deterministic laws through a mathematical approach (Geels et al 2016). This shared set of approaches and disciplines allows for a unified and powerful production of knowledge but may be an obstacle to the integration of social sciences that do not share the same epistemic approach, and are not necessarily familiar with or inclined to consider foresight approaches. For example, some sociological approaches, which generally have a lower propensity for normativity, are more oriented towards highlighting the diversity and evolution of values and practices than toward identifying the regularity of behaviours that could be projected. As observed by Trutnevye et al (2019) a merging strategy between modelling approaches and social sciences comes ‘at a significant cost of simplifying complex descriptions from social sciences into model equations’. We consider that this can both reduce the willingness of social scientist to contribute to the building of pathways and the quality of the explicit knowledge produced by the scenarios.

4.2. Proposals to overcome these challenges

Here we discuss how best practices in the mitigation pathways we reviewed, or—if there is not—in other scientific field could inspire practitioners for more and better consideration of lifestyle changes. In particular we wonder how they could reinforce the three main contributions of the scenarios (explicit knowledge, mediation, framing), regarding the question of lifestyles.

4.2.1. When the modelling framework matters

Quantification challenges mainly concern well-established modelling frameworks, which were initially designed to deal primarily with technical and technological choice issues. There are, however, initiatives that could provide relevant alternatives or complements for further consideration of pathway lifestyles, as the use of MRIO frameworks—of which Vita et al (2019) present a detailed implementation— and, more generally, input-output frameworks.

Other works have proposed frameworks that allow the influence and constraints of social and spatial structures to be better integrated, with rich representations of the heterogeneity of populations and their practices based on the exploitation of surveys on mobility, housing, expenditures or time-use (Weber and Perrels 2000, Raux and Trainsel 2007, Le Gallic et al 2017). However, these data intensive initiatives are subject to limitations in terms of data availability and comparability, particularly when working at the international level. Work to build harmonized datasets, such as that which exists for time use (Multinational Time Use Study (MTUS)), could be valuable to overcome these difficulties.

Also in the direction of introducing richer representations in modelling frameworks, we can mention research that allows the consequences of lifestyle changes on the economic system to be taken into account using hybrid and CGE models, such as in Grottera et al (2020).

Another direction offers a relevant compromise in terms of simplicity and transparency—favourable in particular to participatory processes—while providing a sufficiently detailed framework for discussing lifestyle changes. It includes research based on calculators as (European Climate Foundation 2018, Moreau 2020, Strapasson et al 2020).

4.2.2. … and when it does not matter so much

The literature on IAMs identified the need to integrate learnings of various social sciences in order
4.2.3. Connecting well-being approaches with pathways methodologies

The issue of well-being is central to climate change mitigation. It is reflected in particular in the fears expressed in developed countries regarding transition policies, which poses problems of acceptability and forms a political obstacle, and is the prism through which mitigation strategies are assessed.

The approach that first referred to and is still regularly used is to express welfare losses in terms of losses in overall consumption or gross domestic product (GDP) (Edenhofer et al 2014). The limitations of this type of approach, which are widely recognized (e.g. Stiglitz et al 2009), motivate research on other measures of social well-being, which have recently begun to be implemented in the field of climate change mitigation, as well as in the planetary boundaries framework (O’Neill et al 2018). For example, the latest IPCC Special Report 1.5 °C assessment (IPCC 2018) adopted an assessment based on the sustainable development goals (SDGs) defined by the United Nations (UN General Assembly 2015), whose use in this framework is considered to be part of a multidimensional approach to well-being (Lamb and Steinberger 2017), i.e. recognizing the existence of different irreducible and non-substitutable dimensions that contribute to people’s well-being (e.g. food, health). The multidimensional nature of the lifestyle concept seems particularly well suited to the development of new approaches to well-being in the context of climate change mitigation.

The development of well-being approaches of mitigation pathways should be a new research direction, in line with existing efforts, such as the work of Vita et al (2018, 2020), Millward-Hopkins et al (2020) or of Steinberger and Roberts (2010) who highlight a decoupling of well-being from demand beyond a certain level of demand. Several conceptual and practical approaches also explore innovative solutions to reduce activity levels without compromising well-being through the concepts of prosperity (Jackson 2009), decent living (Millward-Hopkins et al 2020) or sufficiency (Bierwirth 2019). The concept of lifestyle is a pivotal notion for such research, which will thus contribute to improving the assessment of pathways in terms of desirability, and thus feasibility.

4.2.4. Acknowledging the political nature of mitigation pathways and options

There are several reasons why the political nature of pathways should not preclude lifestyle changes from consideration in pathway development. Firstly, most changes related to technologies and to the socio-technical system are value-neutral only in
appearance. As argued by Rosenbloom (2017): "Techno-economic pathways are similarly inclined toward positivist ontological and epistemological assumptions, yet offer policy recommendations based upon implicit value judgements (e.g. the centrality of efficiency) that may mask political and ethical questions." Secondly, any pathway includes assumptions about future lifestyles, even if they are in most cases implicit. Thus, any pathway is value-laden, at least through the conservation of values.

To manage these issues, one direction is to build on the proposals of the STS literature. Beck and Mahony (2018) suggest that experts and institutions that provide assessments should be more aware of the policy-performativity of their scenarios and invest in new framing and assessing methods (e.g. ‘Responsible Research and Innovation’). In the same way Garb et al (2008) suggest strengthening collaboration between scenario practitioners, modellers, and social scientists by using the existing toolkit of social science research to discuss and analyse the ‘social “work” of scenarios’. Sanwal et al (2017) analyse in the case of the IPCC how addressing controversial subjects like achieving well-being within a global carbon budget would involve investing in frameworks that better address interactions between science and policy. To start, future scenarios could include a specific effort in favour of transparency about implicit values and assumptions around lifestyle changes, and this could constitute a new type of dashboard. This direction could be seen as a development of the widely used framework of O’Neill et al (2017), which proposed a set of narratives to help make explicit the societal baseline of global scenarios.

Finally, another way of acknowledging the political nature of mitigation pathways would be to incorporate citizens’ views in the process. Not only can scenario mediation tools be used to support participatory initiatives, as explained in the result section 3.3.2, but they can also benefit from inputs from citizens. For example, citizen climate assemblies, as organised recently in France and in the UK, can enter into a constructive dialogue with the experts, bringing their own political vision on the uncertainties, acceptability and equity of climate policies, including lifestyles changes. Given the potential of these kinds of exchanges, the future development processes of national low carbon scenarios could integrate, in parallel or upstream to the technical work, this type of citizen contributions, which could help to manage the eminently political questions included in these roadmaps.

5. Conclusion

The next generation of mitigation pathways has an important role to play in informing future decarbonisation policies, at both national and international level, and it is crucial to better integrate lifestyles changes in these upcoming assessments. We analysed the scientific, political and methodological implications of lifestyle changes in this context, and discussed existing approaches and promising future directions to overcome some of the obstacles facing the effective integration of lifestyle changes into scenario production processes.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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