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# DELIVERABLE 4.2

## Rebound and Risks Summary Report

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|---|---|
| **Authors:** | Jessika Luth Richter (ULUND), Matthias Lehner (ULUND), Anna Elfström (ULUND), Oksana Mont (ULUND), Josefine Henman (ULUND) and Andrius Plepys (ULUND) |
| **Contributors:** | Edina Vadovics (GDI); Kristóf Vadovics (GDI); Eszter Csiki (GDI); Edina Mihály (GDI), Anita Szőllőssy (GDI), Zsuzsanna Király (GDI), Cecília Lohász (GDI), Dorottya Teveli-Horváth (GDI), Nadin Ozcelik (UDC); Luisa Losada (UDC); Inga Belousa (GL); Kārlis Lakševics (GL); Janis Brizga (GL); Maren Tornow (adelphi); Lena Domröse (adelphi) |

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| EU 1.5 Lifestyles partners | |
|---|---|
| WESTFAELISCHE WILHELMS-UNIVERSITAET MUENSTER (WWU)<br>Schlossplatz 2, Muenster, 48149, Germany | Universität Münster |
| HOT OR COOL INSTITUTE (HoC)<br>Quartiersweg 4, Berlin, 10829, Germany | HotorCool |
| ADELPHI RESEARCH GEMEINNUTZIGE GMBH (adelphi)<br>Alt-Moabit 91, Berlin 10559, Germany | adelphi |
| UNIVERSITEIT LEIDEN (ULEI)<br>Rapenburg 70, Leiden 2311 EZ, Netherlands | Universiteit Leiden The Netherlands |
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| ZALA BRIVIBA BIEDRIBA (GL)<br>Lapu lela 17-3, Riga 1002, Latvia | Zaļā brīvība |
| EUROPEAN RESEARCH SERVICES GMBH (ERS)<br>Hüfferstraße 5, Münster, 48149, Germany | europeanresearchservices gmbh |

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# EU 1.5° LIFESTYLE PROJECT SUMMARY

## POLICIES AND TOOLS FOR MAINSTREAMING 1.5° LIFESTYLES

*The four-year project (2021-2025) EU 1.5° Lifestyles is part of the European Union's Horizon 2020 research and innovation program. It involves researchers, practitioners as well as advisory board members from Finland, Hungary, Japan, Latvia, the Netherlands, Spain, Sweden, and Germany.*

**The project's main aim** is to foster the mainstreaming of lifestyles in accordance with the aspirational 1.5° climate target and to facilitate transformations sought by the Paris Agreement and the EU Green Deal. For this purpose, the project develops guidance for policy makers, intermediary actors and individuals based on scientific evidence on how lifestyle choices affect individual carbon footprints, and how political, economic, and social contexts enable or constrain shifts to sustainable lifestyles options.

**The uniqueness of the project approach** is that it recognises the importance of political acceptance for change, demonstrates potential contributions of individuals and households, and clearly articulates where limited agency by households needs intervention from policy and requires structural changes. In doing so, the EU 1.5° Lifestyles connects analyses of lifestyle perspectives at the household level in the four realms of nutrition, mobility, housing, and leisure with inquiries into relevant political, technological, economic and social structures at various levels of governance.

**To mainstream 1.5 degrees lifestyles**, the project develops practical recommendations, which can be integrated into everyday life as well as into EU and national policies. Along the way, the project provides stakeholders at national and EU levels with:

- a quantification of climate and health impacts on shifting lifestyles in the EU and within three G20 countries (Indonesia, South Africa, Mexico);
- an overview on potentials for and barriers to change at the household level, including options for transitioning to 1.5 degrees lifestyles as well as associated potential risks and opportunities;
- an assessment of structural barriers and enablers for systemic transformations necessary for 1.5 degrees lifestyles;
- assessments of scenarios for economic and welfare systems, and business models compatible with 1.5 degrees lifestyles.

To co-produce outputs and involve target group members, several stakeholder workshops are held, and instructive communication materials are disseminated, including concrete guidance for both citizens and decision-makers on transitioning to 1.5 degrees lifestyles.

# INTRODUCTION

There is a broad consensus that lifestyle changes are necessary to align with the goals of the Paris Agreement (Akenji et al., 2021). Households adopt various strategies, including both sufficiency (i.e., reducing overall consumption) and various circular strategies, such as sharing, reusing, and repairing products. However, alongside these lifestyle changes, there is a risk of rebound effects that can undermine the intended climate benefits (Koide et al., 2019). Understanding rebound effects, their potential mechanisms, and strategies to mitigate them is crucial to realising the full potential of behaviour change as a mitigation strategy.

Work Package 4 (WP4) of the EU 1.5° Lifestyle project assesses the potential risks associated with the lifestyle changes investigated in this research project. Here, 'potential risks' refer to unintended direct, indirect, and other unforeseen consequences resulting from transitions towards 1.5° lifestyles. These consequences are commonly referred to in the literature as 'rebound effects.'

The concept of the rebound effect was initially introduced in the 19th century in the UK by William Stanley Jevons, who observed that more efficient steam engines led to lower coal prices and ultimately increased coal consumption. This phenomenon became known as the "Jevons paradox" (Sorrell, 2009). Since then, it has been more broadly described and studied as the rebound effect. Rebound effects diminish the intended efficiency of technologies and policy measures, often resulting in outcomes that differ from the original plans or expectations. So far, the rebound literature has primarily focused on studies examining the effects of technological improvements (e.g., energy efficiency) and income effects, i.e., the consequences of reinvesting economic savings achieved through technological improvements (Druckman et al., 2011). There has been relatively less attention given to psychologically induced behavioural effects (e.g., "moral licensing") and a broader consideration of impacts (Font Vivanco et al., 2022). More recently, there has been a call to broaden the concept of the 'rebound effect' as awareness grows that low-carbon behavioural changes can trigger a cascade of consequences related to economic, health, or overall quality of life, some of which may be positive and some negative (Hertwich, 2005).

# OBJECTIVES

This report consolidates the outcomes stemming from desk research, workshops, and focus groups conducted in five case countries, along with the mapping and prioritisation of pertinent short-term initiatives and long-term strategies. This report serves as a foundational resource for the second phase of citizen thinking labs within the project, and offers insights to support other work packages in the project. It ultimately also contributes to the formulation of the communication strategy and policy recommendations.

# LITERATURE REVIEW – REBOUND EFFECTS

In the following section, we will begin by detailing the methodology employed for conducting this literature review. Subsequently, we will delve into the current state of knowledge concerning the rebound effect. Initially, our focus will be on the direct economic rebound effect, representing the narrower definition. Following this, we will introduce and explore the less understood yet equally significant expanded perspective on rebound effects.

## METHODOLOGY FOR CONDUCTING THE LITERATURE REVIEW

A literature review is defined as *'a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents'* (Fink, 2013). Our literature review adhered to established guidelines commonly used in management and social sciences (Green and Higgins, 2008) and is organised into three primary phases: planning the review, conducting the review, and reporting and dissemination. The phase of 'conducting the review consists of three distinct steps: database search, supplementary search, and conclusive search, as recommended by Fischer et al. (2017).

To initiate the process, we established formal search parameters for the database search, which included the following:

Table 1: The sample inclusion and exclusion criteria.

| Criterion | Sample inclusion | Sample exclusion |
|---|---|---|
| **Search scope** | SCOPUS database | Other databases |
| **Source** | Peer reviewed journal articles, book chapters, conference papers and dissertations | Any other source, e.g., newspaper articles, reports and other |
| **Type of research** | Empirical and conceptional work | NA |
| **Time period** | Publications published until May 31, 2023 | Publications published after May 31, 2023 |
| **Search parameters** | Search string terms appear in all or in the title, abstract, or author-supplied keywords | Search string terms do not appear in all or in title, abstract or author-supplied keywords |
| **Language** | English | Other languages |

Then, different search strings were constructed using different keywords combined using the Boolean logic and operators, such as AND and OR: e.g., 'rebound effect', 'sustainable', 'household' , 'lifestyle', 'individual'.An example of a search string is illustrated below:

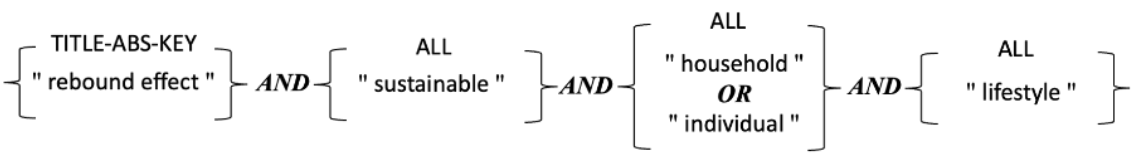


Figure 1: Main search string.

This search string yielded 82 articles in Scopus database. Ten more articles were added through "bread crumbing" approach, when the reference section of a given publication is examined to identify other eligible works (Fink, 2013). This supplementary search yielded 10 more articles. The final sample was 92 articles, titles, abstracts and keywords of which were examined for relevance.

In the next step, specific searches for rebound and particular lifestyle changes (50+) were conducted. A sample search string is shown below:

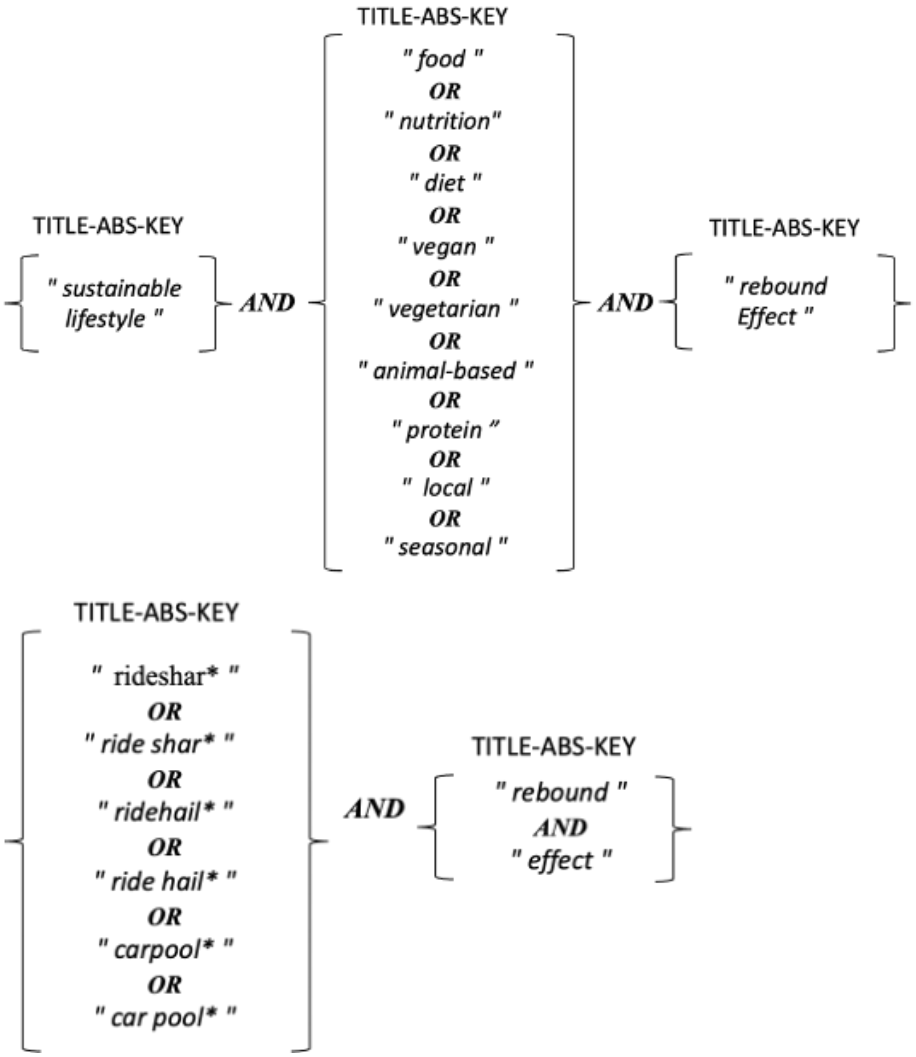


Figure 2: Examples of specific search strings for different lifestyle options.

In each domain, the final set of articles comprised the following: 15 articles in the nutrition domain, 36 articles in the mobility domain, 38 articles in the housing domain, and 23 articles in the leisure domain. The abstracts of these articles were reviewed to assess their relevance. It's worth noting that a significant portion of these articles overlapped with those found in the main search. Only 12 unique articles were identified and added to the final sample, resulting in a total of 114 articles. Additionally, we conducted a separate search on work time reduction and

its side effects, which yielded 10 more articles, bringing the final sample to a total of 131 articles.

The team then proceeded to read and code the final sample of articles using NVivo 12, a software designed to organise, categorise, and code qualitative data. This coding process involved three researchers and encompassed categorising the articles based on domain of consumption, types of rebounds, magnitude, specific lifestyle options considered, and measures to address rebound effects. The codes emerged through a series of inductive-deductive iterations (see Figure 3 for examples of codes).


Figure 3. Examples of codes used for literature review in NVivo.

The following sections present the findings resulting from analysis of the 131 articles structured and then by lifestyle options.

## TYPES OF REBOUND EFFECTS

In broad terms, the literature we reviewed discusses three primary mechanisms through which rebound effects manifest: economic, psychological, and time-use related mechanisms. Furthermore, the literature distinguishes various levels of rebound effects, spanning from direct to indirect and economy-wide (or macroeconomic) effects. This taxonomy primarily stems from economic explanations of rebound effects. However, it is essential to note that in this project, we adopt a broader and more inclusive definition of rebound effects. This definition encompasses a wide range of outcomes beyond the economic sphere, recognising their potential impact on individuals' well-being, the living environment, and social structures.

Rebound effects can be positive and negative. **Positive rebound effects** refer to the reduction in expected gains from an action, i.e., technological or behavioural changes. A **negative**

**rebound effect** may occur when the cost of implementing the action increases, resulting in a reduction of GHG emissions induced by altered technology or behaviour. For example, shifting from a high-impact meat-based diet to a local organic-based diet may result in negative rebound effects because locally-produced organic food is often more expensive. Thus the cost savings from shifting to a non-meat based diet are spent on more expensive alternatives with lower environmental impacts.

On the opposite end of the spectrum, if the impacts from the resulting re-spending are high enough, it can result in what is called a **backfire effect** (Saunders, 1992). This can occur in the situation where efficiency gains from a new technology, behaviour change or a policy measure are surpassed by behavioural or systemic responses, leading to an increase in resource consumption or emissions rather than a decrease (Druckman et al., 2011).

## Economic mechanisms

Most of the literature on rebound effects originates from economic studies and categorises them as direct, indirect, and economy-wide (as seen in Greening et al., 2000), although these categories are not always consistently defined. Below, we provide a synthesis of the prevailing understanding of these categories.

**Direct rebound effects** typically pertain to an increase in demand for or usage of a product or service. This increase can be induced by improvements in material, energy, or production *efficiency*, which subsequently lower the life cycle costs of products. Efficiency enhancements are often driven by technological innovations or are induced by policy interventions that promote technological, product, or business model innovations. Examples include energy efficiency standards or policies that influence consumer decisions and market demand, such as green public procurement and eco-labeling. For instance, a direct rebound effect may occur when consumers install energy-saving lamps at home, but end up using them more intensively or buying and installing more lamps than they had before, thus offsetting the energy savings.

**Indirect rebound effects** commonly refer to secondary effects resulting from the re-spending of monetary savings on the consumption of other goods and services, with associated environmental impacts (Gillingham et al., 2016). For instance, a consumer may switch to more energy-efficient lamps and use the savings to consume another good or service, like taking a vacation, often referred to as the 'lights to flights' phenomenon (see Chitnis et al., 2013). The economic savings are often termed the 'income effect,' while there is also a 'substitution effect' where relatively less expenditure occurs on lighting and more on other goods or services (Reimers et al., 2021).

At a higher level, both direct and indirect effects result in savings and alterations in consumption patterns that reverberate through multiple layers across different economic sectors. These effects are often referred to as **economy-wide effects,** where lower costs can

lead to increased industrial outputs (Greening et al., 2000; Jenkins et al., 2011). This then affects the supply-demand balance resulting in price changes for various goods and services. These economy-wide effects can create a feedback loop that influences consumption behaviour.

Research on rebound effects further distinguishes between *efficiency-based* and *sufficiency-based* rebound effects, categorising them based on the nature of the triggering behaviour change. Efficiency rebound effects arise when individuals shift to using products that are more energy-efficient, thereby reducing the energy consumption per unit of the product. In contrast, sufficiency rebounds stem from an absolute reduction in the consumption of products. It is important to note that behavioural changes can also manifest in ways that are not strictly related to efficiency or sufficiency. For example, shifting from a diet that includes meat to a vegetarian diet represents a behavioural change that can have environmental impacts.

Nelldal & Andersson (2012) have classified such triggering behaviours as 'mode shifts.' All these behaviour changes have the potential to result in rebound effects, but the nature and extent of these rebounds can vary depending on the specific triggering behaviour. For instance, sufficiency behaviours may not directly result in rebounds in the same consumption domain but can indirectly lead to rebounds in other consumption categories. This indirect rebound occurs because the economic savings induced by reduced consumption in one domain can then be redirected toward increased consumption in other areas (Chitnis et al., 2013).

The term **'embodied rebound effect'** refers to the increase in energy or resource consumption that occurs indirectly as a result of energy efficiency improvements. This increase is often due to the energy and resources embodied in the lifecycle of materials, products, and technologies used for the efficiency measures themselves. For example, the production of energy-efficient appliances or insulation materials may consume energy and resources, offsetting some of the gains made by the efficiency improvement, see (Chitnis et al., 2013; Freire-González et al., 2017; Sorrell, 2009).

While much research is focused on consumer behaviour change, often the triggering mechanism is not explicit and/or conflated with policy interventions that improve efficiencies and can induce diverse changes in products, markets, and consumer behaviours. Previous research (e.g. Castro et al., 2022; Gillingham et al., 2016) refer to policies, strategies, business models and other transition-induced changes as "initiating mechanisms" that, in turn, can trigger consumer behaviour changes and also changes in the production system (e.g., through substitution effects) and the wider economic system.

Rebound effects are also further categorised and studied by the mechanisms through which they occur. The direct, indirect and economy-wide rebound effects described above have been studied by examining primarily economic mechanisms, associated with economic savings, income, spending and micro and macro effects to the economy. Rebound studies on economic mechanisms are most often quantitative (Figge & Thorpe, 2019; Makov & Font

Vivanco, 2018; Zink & Geyer, 2017) and focussed on income effects mostly in the energy domain (Reimers et al., 2021; Vita et al., 2019; Wood et al., 2018).

## Psychological mechanisms

There are also studies exploring psychological mechanisms of rebound effects. An important theory is **moral licensing**, which essentially argues that after doing a good deed (moral action), e.g., buying a more efficient product or reducing consumption in one area, an individual may feel they can then compensate with a less good or even "bad" behaviour or action (Bauer & Menrad, 2020; Burger et al., 2022). While the subsequent behaviour is the same as in the examples of economic rebound, e.g., a consumer going on vacation after installing efficient lighting, the mechanism is different as the behaviour is driven not only by the availability of savings or income but by the moral licensing effect. For example, the individual chooses to fly because they feel justified by lowering their environmental impact in one consumption domain to engage in a subsequent high environmental impact in another area of their lifestyle.

However, moral licensing is not a given psychological response; whether it occurs is also related to moral consistency and moral balancing (Cornelissen et al., 2013). **Moral balancing** is when people consider trade-offs and consequences, while **moral consistency** is when people are guided by rules and integrity. The former is associated with moral licensing, while the latter generally inhibits it for individuals with strong environmental values and a rule-based mindset, see, e.g., Bauer & Menard (2020). Seebauer (2018) suggests that the level of self-awareness is also important as people rarely agree that they are explicitly compensating or doing any mental accounting for pro-environmental behaviours if these are very different in terms of domain, effort and costs. However, Dreijerink et al. (2021) also suggest that even when people are aware that moral licensing and rebound effects could occur, they often miss some of their own behaviours and have a tendency to underestimate the negative impact of their behaviours. Dütschke et al. (2018) argue that moral licensing and its effects on consumption rebounds are important phenomena and should be considered in policies targeted at energy efficiency improvements.

Adding to the complexity, the triggering behaviour itself can influence subsequent behaviour. This is often referred to as **spillover effects**. After making one behaviour change, a person might make similar changes in the same or other domains (Seebauer, 2018). For example, installing energy efficient appliances could also induce additional environmental behaviours, with similar effort and cost, notes Seebauer (2018); but again, Bauer & Menard (2020) found that this is only the case for individuals with environmental values and guided by rules.

## Time-related mechanisms

While most studies consider consumption as limited by the income, or purchasing power, of the consumer, it is also limited by time (Jalas, 2002). New innovations or behaviour changes induce changes in monetary savings or further behaviour changes and changes in time use.

Thus, rebound effects can be studied not just in how consumers spend money or act but also on what consumption activities they choose to spend their available time. Use of time is not only based on decisions by the individual but is influenced by social structures. This can make patterns of time use difficult to change. In addition, time, in particular, discretionary time and how it is used, has social effects, e.g., on stress (Jouzi et al., 2021).

Time use rebound research originated in mobility studies and often focuses on macro effects that show that increasing efficiencies and speeds of transportation have enabled longer distances and increased travel overall (Font Vivanco et al., 2022; Kim et al., 2020). Studies have also focussed on the environmental impacts of activities and how changing allocation of time use for different consumption activities can change overall environmental impacts (Bieser & Hilty, 2020). Different activities can have different environmental intensities (e.g., compare reading a book vs. taking a Finnish sauna).

Lastly, the rebound effects themselves can be categorised by the type of effects that are observed or measured. Prior literature has often examined and measured the effects in terms of energy consumption, but some more recently in terms of greenhouse gas (GHG) emissions. Some also only consider energy use instead of the lifecycle use of energy (i.e., also referred to as lifecycle energy). The approach towards what effects are included and how they are measured significantly changes the magnitude of effects (Chitnis et al., 2014).

# REBOUND EFFECTS BY CONSUMPTION DOMAIN AND FIFESTYLE OPTION

In this section, we focus on describing rebound effects associated with the four consumption domains the EU 1.5° Lifestyle project focuses on: mobility, housing, nutrition, and leisure, along with specific lifestyle options identified in Work Package 2 of the project[1]. Where possible, we attempted to illustrate the scale of direct and/or indirect effects available from the reviewed literature. Please observe that the presented quantitative estimates should be treated only as indicative, since they are most often the results of case-based estimates. The magnitudes of rebound effects depend on the specific contexts of case studies with fairly heterogeneous variables, as well as different models with their assumptions and diverse boundaries, both of which have a significant influence on results.

## Mobility

Many studies consider different effects that result from travel-related behavioural changes, summarised by Coulombel et al. (2019) as a travel mode shift effect, route choice and adjustment effect, distance effect, and relocation effect. Many have also examined the

[1] The methodology for the selection of lifestyle options can be accessed through the EU 1.5° Lifestyle website: https://onepointfivelifestyles.eu/sites/default/files/attachment/2023-03/WP2%20-%20METHODOLOGY%20FOR%20THE%20SELECTION%20OF%20LOW-CARBON%20LIFESTYLE%20OPTIONS_1.pdf

rebound effects associated with ridesharing, carpool, and car-sharing services. Coulombel et al. (2019) argue that the cost savings from sharing can lead to fewer vehicles and less congestion, but can induce more car usage and longer driving distances.

However, rebound estimates for car sharing vary significantly. For instance, in a case study of ride sharing in Paris, Coulombel et al. (2019) estimate that the size of the rebound effect is between 68% and 77% (i.e. the reduction of initial GHG emissions savings), corroborating earlier research in several North American cities by Shaheen et al. (2016) and Xu et al. (2015).

Estimates on rebound effects are highly contextual and depend on assumptions, system boundaries and a multitude of contextual variables. The latter include, for instance, the design and costs of other mobility alternatives, income levels, price and household income elasticities, etc. For instance, in the U.S. settings, Chen & Kockelman (2016) estimate the direct rebound effects at as low as 5% and indirect - at 3%, while Vélez (2023) found as high as 70%-85% for both direct and indirect for a case of Amsterdam. Modelling results by Font Vivanco et al. (2015) for different mobility scenarios in Europe found a direct rebound effect of 40% and an indirect environmental rebound effect of 135% due to re-spending on activities with higher environmental intensities, such as flying, which aligns with earlier studies of sharing cases by Hertwich (2005) and Briceno et al. (2005).

Ottelin et al. (2017) found that reducing driving leads to a rebound effect in Finland ranging between 11-41%, with an average of 23%, which is in line with findings by Chitnis et al. (2014) and Druckman et al. (2011). The same study by Ottelin et al. (2017) estimates even higher rebound effects of 68% for an average middle-income Finnish person who gives up a car. It is assumed that the savings are re-spent on average consumption and that other forms of travel, particularly flying, are significant drivers of this rebound. Vita et al. (2019) similarly found that if the savings from cycling in Europe are re-spent on flying, it offsets the emissions saved. A Norwegian study found that after buying an electric car, the rebound effects can range from -50% to +50%, depending on the cost of the car and the potential for re-spending in high-impact consumption domains, as noted by (Bjelle et al., 2018).

In the realm of teleworking, it has the potential to reduce commutes and distances travelled, as found by Caldarola & Sorrell (2022) in the UK and the modelled case of Chicago by Shabanpour et al. (2018). However, a growing body of research indicates that teleworking may encourage people to live farther from work if they do not need to commute daily, as found by Cerqueira et al. (2020), de Vos et al. (2018) and Zhu (2012). People may switch to teleworking but also shift to less sustainable mobility modes, as observed by Ceccato et al. (2022) and Hensher et al. (2021). The energy efficiency of workplaces versus homes also affects the total impacts and rebounds from teleworking, as pointed out by Guerin (2021).

There is thus a significant diversity in the number of studies considering different travel-related lifestyle options. While many studies estimate, measure, and model the rebound effects of telework, hardly any have analysed the effects when people move closer to the workplace or opt for public transport instead of owning a car. The size of rebound effects

associated with different behavioural changes spans a wide range as illustrated above.

### A smaller car or a shift to a less $CO_2$-intensive car from own SUV

A theoretical study assumed that smaller cars consume less fuel and thus emit less. However, these cars also cost less and thus, more people can afford them. This may lead to more cars on the streets and eventually higher congestion. Congestion, in turn, may lead to higher fuel consumption and higher emissions levels (Saptoadi, 2016).

### Ridesharing-carpool

Many studies on rebound effects lump together ridesharing/carpooling and car-sharing services. In this section, we specify what focus the studies have. When passengers share rides (ridesharing and carpooling), the cost of a ride is also shared. This cost splitting may result in many more shared rides, which otherwise could be avoided or not afforded. On the other hand, sharing rides leads to fewer vehicles on the road and reduced congestion. This may also cause several behavioural changes, such as making fewer "detours to avoid congestion (route choice effect), switching from public transit and active modes to the car (modal shift effect), travelling longer distances (distance effect), and relocating further from the urban centre (relocation effect)" (Coulombel et al., 2019). It is suggested that the modal shift effect is the first to be activated, followed by the distance effect when people drive longer distances. Finally, the relocation effect is the last and less prominent effect than the other two. The size of the rebound effect is between 68% and 77% in terms of $CO_2$ emission reductions. The modal shift effect is responsible for more than half of the overall size of the rebound effect. The rebound effect decreases slightly as average vehicle occupancy increases. These findings confirm the earlier research on the rebound effects of ride-sharing. For example, the study by Shaheen et al. (2016) shows that "casual carpooling attracts riders from public transit.

Xu et al. (2015) indicate that when traffic congestion costs decrease due to ridesharing, more travellers drive alone, and fewer people join ridesharing. Cost savings on sharing rides leave more disposable income in individual budgets, which can be spent on driving solo. Specific suggestions for combating these rebound effects are to improve public transport, reduce road capacity, and increase the cost of travelling by car solo (Coulombel et al., 2019). However, it is demonstrated that improving public transportation reduces the effectiveness of ridesharing, and thus, these two measures should not be combined. On the other hand, reducing road capacity is synergetic with ridesharing. It reduces $CO_2$ emissions by 13% while incurring a 9% increase in social costs from increased congestion and longer rides (Coulombel et al., 2019). Introducing a dedicated tax on road use or fuel prices following the reduced transportation costs associated with ridesharing significantly limits both the modal and distance shifts.

### Switching to an electric car

Regarding changing to an electric car, rebound effects depend on whether it is a budget electric car or a top-of-the-line electric car. A study by Bjelle et al., (2018) shows an average rebound effect of switching to a budget electric car to be 48%, while for the top-of-the-line electric car, the effect is a negative average rebound of -45%. This is explained by the fact that while shifting to a budget car leads to monetary savings and may cause the re-spending rebound effect, buying a top-of-the-line electric car reduces or even negates this rebound.

### Walking or cycling instead of owning a car

Even when people switch from driving a car to walking and cycling, there might be several rebound effects that may reduce the benefits of the switch. The primary mechanism is re-spending money saved on not owning or driving a car and spending money on high-energy-intensity activities, such as flying. Walking or cycling instead of using a car "for trips of less than 2 miles" (ca. 3 km) in a UK-based case study resulted in a rebound effect of 25% (Druckman et al., 2011). In the case of people shedding car ownership and not using a car, a study from Finland estimates that the average GHG rebound effect equals 68% for an average working middle-income Finnish person (Ottelin et al., 2017). In this case, it is assumed that the savings from shedding a car are re-spent on average consumption, excluding housing and personal vehicles, and that other travel, particularly flying, is a large driver of the effects. These findings are confirmed in a recent study that analysed the indirect effects of not owning a car and identified a positive correlation with long-distance flying (Andersson & Nässén, 2023). However, Czepkiewicz et al. (2020) reviewed 27 case studies in 11 countries and found that car ownership was also positively associated with international leisure trips and interpreted that higher incomes afford to spend on both cars and flights.

### Driving less

Driving less – reducing vehicle-kilometres travelled – e.g. eliminating car journeys of less than 3 kilometres leads to direct and indirect effects of 28% in a UK study (Chitnis et al., 2014). A Finnish study demonstrates that the average rebound effect for reduced driving alone is only 23% (Ottelin et al., 2017), and ranges between 11% and 41%. These results align with studies by Druckman et al. (2011) and Chitnis et al. (2014). The study also shows that the carbon footprints are lowest, not for people who do not own a car, but rather for people who own a car but drive very little. The regression model shows the difference to be 11%. This is explained by the fact that after a car is sold, the released funds are spent on other modes and types of travel, such as trips abroad (see flying for leisure option below). Other consumption categories of car-free singles and couples are services and tangible products.

### Public transport instead of own car

Although switching from driving one's own car to public transportation reduces environmental

impacts, there might be rebound effects associated with the shift. Once the marginal costs of travel by public transportation are lower, people may make more trips than they otherwise would or choose to live further away from their workplaces (Babutsidze & Chai, 2018). Also, the induced monetary savings can be re-spent on other goods and services that could be more carbon-intensive than driving a private car. In addition, choosing public transportation may induce the moral licensing effect, making individuals feel they have "done their bit" and leading them to be less diligent in other areas (Babutsidze & Chai, 2018).

**Moving closer to the workplace when moving house**

When people move closer to the workplace, the environmental impacts might not be reduced as intended for several reasons. Czepkiewicz et al. (2020) note that in earlier studies people re-spend the time and money from reducing daily travel on longer distance leisure travel instead. Saving from reduced costs of commuting can be spent on more energy-intensive activities, thereby leading to rebound effects.

**Working at a home office and telework**

The Covid pandemic spurred much research on the effects of teleworking on the environment. Teleworking can reduce energy, time spent commuting, and distances travelled (Shabanpour et al., 2018). An older Finnish survey-based study also demonstrated that telework reduced the total kilometres travelled by 0.7%. These studies primarily focus on peak-hour travel. On the other hand, many studies show that telework may encourage longer distances to work as people might want to settle further away if they do not need to commute daily (de Vos et al., 2018; Zhu, 2012). Teleworking may also spur more trips for other purposes than work, such as shopping or caring for children. It may also influence the travel patterns of other members of the household (Caldarola & Sorrell, 2022). Findings from England demonstrate that teleworkers tend to travel further and have more non-work-related travel. This confirms findings from an earlier study that reported increased travel by all mobility modes, especially by car in one-worker households (Abreu e Silva & Melo, 2018).

Another study found that teleworkers report longer commute distances and higher $CO_2$ emission levels (Cerqueira et al., 2020). However, according to Caldarola & Sorrell (2022), those who telework three or more times per week tend to have less private travel than those who do not telework. Families with at least one teleworker tended to travel more per week than families without (Caldarola & Sorrell, 2022). The study also showed that teleworkers tended to have more business trips. These findings confirm the results of an earlier study (Kim et al., 2015). A mobility survey from Padova, Italy, showed that although many people switched to teleworking, they also shifted to less sustainable mobility modes (Ceccato et al., 2022). Similar findings were arrived at in an Australian study (Hensher et al., 2021). In addition to mobility-related aspects, the energy efficiency of workplaces and homes affects the total impacts and rebounds from teleworking. For example, in a study by Guerin (2021), telework had a lower environmental impact for employees who travel more than 30 km on workdays. If the energy

use at home became more than 1212 kWh per year, the environmental impacts of teleworking were higher than savings. Thus, all these studies point to the fact that telework leads to longer distances travelled by teleworkers for non-work-related purposes.

Bieser et al., (2022) conducted a literature review and concluded that most studies about rebound effects of teleworking focus on travel impacts and leave time-related changes in teleworking unexamined. In their study, they focus on the time spent on commuting and alternative uses of the saved time if people work from home. They demonstrate that spending reduced commute time on low energy-intensive activities such as sleep, leisure, and personal, household and family care is likely to reduce energy use. On the other hand, using saved time on high energy-intensive activities, such as private travel, cooking at home, and high energy-intensity leisure endeavours, may even result in increased energy consumption. The reduction potential also depends on the mobility mode that teleworking is substituting. For people commuting by car, energy reductions could be substantial. In contrast, for those who commute by active mobility means, i.e., walking and biking, there will likely not be any energy reductions.

Despite the wide range of studies on teleworking and its environmental impacts and rebound effect, no definite conclusion can be made on whether it is more environmentally sound to telework or work from office (O'Brien & Yazdani Aliabadi, 2020).

### Car-sharing services

A paper by Vélez (2023) demonstrates that users of car-sharing schemes who do not own cars can reduce their $CO_2$ footprint by about 40% (the case of the Netherlands). Car-free users who started using car sharing for 3% of their kilometres travelled by car increased their $CO_2$ footprint by 0.42% to 0.70%. The rebound effects of re-spending can be between 70% and 85% due to non-mobility-related consumption. A study by Chen & Kockelman (2016) showed that US citizens who use car-sharing services reduce their average mobility-related energy use and GHG emissions by 51% due to mode shifts and avoided travel, reduced demand for parking space and lower fuel consumption. These savings are then translated into 5% savings in all household mobility-related energy use and GHG emissions in the US. The estimated indirect rebound effects reduce this figure by 2%.

A study by Font Vivanco et al. (2015) demonstrated that car-sharing organisations in Europe caused a 40% increase in overall global warming potential emissions. The indirect environmental rebound effect is 135% due to the reduced mobility costs resulting from car sharing and the re-spending of savings on consumption categories with higher environmental impacts. These align with earlier studies by Hertwich (2005). Findings of a Norwegian study show that if the savings are equally distributed between different non-mobility consumption categories, rebound effects are relatively small; however, if the savings are spent on air travel, the rebound effects are significant (Briceno et al., 2005).

### Autonomous cars

An additional option that was discussed in the literature was autonomous driving. It is expected that automated and connected cars will allow a smoother flow of traffic, increase flexibility for users, reduce the idling time of vehicles and could potentially reduce the number of vehicles in operation by between 31% to 95%, leading to reduced congestion and emissions from traffic (Spieser et al., 2014). In addition to technological innovation, automated cars are expected to significantly increase the acceptance and spread of car sharing (Bischoff & Maciejewski, 2016; Krueger et al., 2016).

On the other hand, automated cars could lead to increased demand for autonomous vehicles due to higher levels of comfort and improved quality of time during trips (Payre et al., 2014), often at the expense of public transport. Furthermore, the cost of trips by shared automated cars might be much lower than the present-day taxi cost, increasing user demand (Burns, 2013). This could result in a direct rebound effect when users can afford more trips. Due to the higher quality of time in automated cars, people might be interested in taking more and longer trips (Krueger et al., 2016). The use of autonomous cars is also expected to lead to 8% to 17% more unoccupied car kilometres travelled for relocation of vehicles (Davidson & Spinoulas, 2016). It is also feared that due to unavailability or high prices of parking places, autonomous vehicles will drive around until they are requested by the next user (Pakusch et al., 2016).

## Housing

Significant reductions in a household's climate footprint can be achieved by reducing energy use in housing. This primarily includes more efficient use of energy for lighting and heating. Additional reductions in climate impact can be achieved by purchasing greener energy, living in smaller dwellings, and sharing living spaces with more people. The most effective strategies for direct energy savings are related to sufficiency behaviour changes, such as living in a smaller dwelling, sharing living space, or reducing indoor temperature. Among technical measures, the most effective for direct energy savings include installing more efficient lighting, insulation, solar PV, solar thermal heating, and heat pumps.

However, as with most efficiency improvements, both direct and indirect rebound effects occur. Their mechanisms are fairly similar across different consumption domains, although economic mechanisms are perhaps more prevalent in the housing and energy sector than psychological ones. Characteristic to housing energy efficiency improvements are the rebounds stemming from the energy embodied in the life cycle of improvement measures, such as materials, products, and technologies.

The size of rebound effects depends on energy efficiency measures adopted. Sorell et al. (2009) suggests that overall, the direct rebound effects from different residential energy efficiency improvements, including insulation, on average could be around 20-30% (Sorrell et al., 2009). Chitnis et al. (2013) estimated that the rebounds associated with reducing indoor

temperatures by 1°C is only 7%, while other heating and energy efficiency measures result in a rebound of around 12-13%. Embodied energy adds an additional 10-20% for measures like lighting and insulation, or up to 67% for solar thermal systems. Rebounds from home insulation measures alone could be ca. 12% and ca. 25% for direct and embodied rebound respectively (Chitnis et al., 2013). Bardsley et al., (2019) also found a direct rebound effect of up to 40% with thermal upgrades to housing in the UK. Rebound effects from efficient lighting are estimated at 6% in Germany (Schleich et al., 2014) or 5-15% in the UK (Chitnis et al., 2013).

Rebound effects from households adopting solar photovoltaics (PV) were estimated at 5-8% in California (Kim & Trevena, 2021) and 7% in the Netherlands (Aydın et al., 2023). Meanwhile, studies accounting the effects of feed-in tariffs of home-produced PV electricity estimate higher rebounds at different price levels, such as up to 15%-20% in Australia (Deng & Newton, 2017) and 5-33% in Germany (Galvin, 2015). Rebound effects also depend on household income. For instance, installing heat pumps results in rebounds ranging from 10% in wealthier OECD regions to up to 60% in poor regions (Raynaud et al., 2016). Household behavioural characteristics, such as awareness levels, behavioural norms, and social pressures, are also important in determining the size of rebounds (Gillingham et al., 2016).

The above estimates of the size of rebound effects should be treated only as indicative as they are derived from case-specific case studies with multiple variables. Important variables affecting the size of rebound effects in the housing sector include prices of alternative energy sources, feed-in tariffs, different subsidies, price and income elasticities, various technology characteristics, the size of generated savings from lifestyle changes, and various psychological aspects (Freire-González, 2017; Santarius & Soland, 2018).

**Improving thermal energy efficiency of living areas**

Climate savings in the housing consumption domain can be achieved through technological solutions and behavioural adaptations. Technological solutions could, for instance, be better insulation or more energy efficient lighting. Behavioural changes could be buying greener energy or adapting sufficiency strategies, such as reducing indoor temperature, and reduction of living space. However, rebound effects can occur whenever households perceive economic savings or feel deserving a reward for good environmental deeds.

Chitnis et. al (2013) estimated the combined direct and indirect rebound effects from seven energy efficiency measures among UK households including different options of insulation, solar thermal heating, solar PV power generation, efficient lighting, and reducing room temperature. The study took into account income elasticity and greenhouse gas (GHG) intensities of 16 categories of goods and services as well as the embodied emissions of the measures themselves and their capital cost. The rebound effects were measured in GHG for an average UK household and the prevailing UK energy mixes. The rebound effects from income effects alone of all measures were found to be typically around 12%. The direct rebound effect was around 1.5% and the remaining 9-10% was from re-spending the generated

economic savings. In other countries with less carbon-intensive heating systems and greener electricity grids, the rebounds may be much larger (Chitnis et al., 2013).

A significant addition to rebound effects can be from the environmental impacts embodied into energy improvements themselves. The impacts are the emissions of the lifecycle of equipment such as more efficient boilers, insulation materials, PV cells, solar thermal panels, or energy efficient lighting. According to Chitnis et al. (2013) the embodied impacts can add between 2% and 67% to the rebounds. For LED lighting embodied effect can be up to 20%, for cavity wall insulation - 10%, for loft insulation - 49% and 67% for solar thermal energy systems (Chitnis et al., 2013). Bardsley et al. (2019) also estimated a similar rebound effect (up to 40% of income effect and embodied energy) for diverse thermal upgrades in the UK.

**Efficient lighting**

According to IEA, lighting uses about 19% of electricity in the world and 14% in the European Union (De Almeida et al., 2014). Switching to more efficient lighting is a relatively easy measure to reduce households' climate impacts. During the past decade, the inefficient incandescent lighting has been largely phased out from the European market and replaced by compact fluorescent (CFL) and LED lamps. This has resulted in significant energy savings of up to 90% for LED and 70% for CFL.

However, the adoption of efficient lighting solutions can often result in extended usage hours or putting more lights, thereby partly offsetting some of the energy savings (Sorrell & Dimitropoulos, 2008). The resulting cost savings also induce indirect rebounds through re-spending on additional consumption of other goods and services (Gillingham et al., 2013). The rebound from switching to LED was found to be at 6% in Germany with 60% of it arising from higher luminosity and the rest – from longer use of lighting sources (Schleich et al., 2014). Chitnis et al. (2013) estimated the rebound effects in terms of GHG emissions from lighting to be 5–15% in the UK, where the direct effects on average were below 2% and indirect effects of re-spending – around 13%. These goods and services were found to be generally much less GHG-intensive than energy consumption in e.g., the UK energy mix (Chitnis et al., 2013). In countries with greener electricity mixes the GHG rebounds of re-spending could be higher compared to energy impacts from direct rebounds.

The magnitude of rebound effects from energy efficiency improvements of lighting is also contingent to income elasticities (Blum et al., 2018). With increasing incomes, lighting is no longer considered as a luxury good today and light consumption is gradually reaching a saturation level, which basically means that when light is perceived as more affordable due to increasing household income and decreasing price elasticity, it will result in relatively marginal increases in direct light consumption (Fouquet & Pearson, 2012). However, indirect effects of re-spending still occur. For instance, live information regarding energy consumption can also be an effective measure to reduce direct consumption, but re-spending of savings will still take place. Jessoe & Rapson (2014) found that providing households with real-time feedback

on electricity consumption can lead to a 4-12% reduction in overall electricity use, but does not significantly alter the overall rebound effect from lighting efficiency improvements (Jessoe & Rapson, 2014).

### Installing heat pumps

Installing a heat pump can be an effective way for households to reduce their climate footprint of home heating. They can provide up to 3-4 times more heat energy than the electrical energy they consume. Heat pumps are attractive due to their versatility in providing zoned climate control including both heating and cooling. Many countries today have support programs with financial incentives for installing heat pumps, making them an economically attractive option for households, but it is important that electricity is sourced from renewable sources.

At the same time, although compared to conventional electric heating, heat pumps have the potential to reduce electricity consumption by up to 25%, the savings can be at least partly eroded by rebound effects (Halvorsen et al., 2016). The main reasons include the potentially lower heating costs, more convenience, and additional heating/cooling functions. Rebound estimates range broadly and depend on particular technology characteristics, as well as income levels. For instance, in richer OECD regions the rebound effects are estimated at 10% and up to 60 % in fuel-poor regions (Raynaud et al., 2016). A review by Sorrell et al. (2009), included heating systems with heat pumps, found that the rebound effect could range from 10% to 30%. The size can be influenced by policy measures, when subsidies for heat pump installations may induce households thinking that the running costs are lower and more heat is now affordable (Sorrell et al., 2009). According to Qiu et al. (2017), the effect of subsidies could result in rebound effects of up to 15%.

The rebound effect can also be influenced by consumer awareness and attitudes. Households that are more informed about the environmental benefits of heat pumps are generally less likely to experience a significant rebound effect (Galvin, 2015; Labanca & Bertoldi, 2018). In a Norwegian study, Halvorsen et al. (2016) utilised a large-scale qualitative household survey along with in-depth interviews. The main causes of rebound effects were identified as the manner in which people installed the heat pumps, the energy sources that were substituted, and whether additional heating or cooling options were added to existing systems. In more than half of the cases, households installed heat pumps during renovations, replacing older, more expensive, and often fossil-based fuels. Although total energy consumption decreased, the behavioural response led to higher electricity use than necessary. This was because households perceived that they were achieving significant savings compared to older heating options. In several instances where heat pumps were added to existing heating solutions, households often opted for higher comfort levels, such as increased indoor temperatures, or began using the cooling function. The ease of use of heat pumps also led to an extension of heating time, especially when compared to firewood stoves (Halvorsen et al., 2016).

### Installing solar PV panels

Households adopting local green electricity production technologies, such as solar PV cells, can also reduce their climate footprint. An average solar household can generate up to 40% of its total electricity consumption. Being much less dependent on the local electricity grid, they are also less exposed to price fluctuations. However, while on one hand households' disposable income is affected by the capital costs of solar cells, they can also perceive that they are producing "free electricity", which in turn can induce behavioural rebounds. Indeed, households with their own solar PV electricity production have been reported to have higher levels of electricity consumption relative to those without PV (Deng & Newton, 2017).

The magnitude and the causes for rebound effects from solar PV are case specific and depend on different variables. For instance, the level of feed-in tariff is an important variable determining the size of energy rebound effect among households producing their own PV energy and able to sell surplus energy to a city grid. When the feed-in tariff is small, households tend to consume more of "free" own-produced electricity. According to an Australian study, the rebound effect can reach up to 21% (Deng & Newton, 2017).

A Dutch study of households without feed-in contracts estimated the rebound effects from PV at 7.7% (Aydın et al., 2023). It also found that households adjust their consumption to the time periods when solar electricity production is higher, which suggests that rebound effects are heterogeneous over time and production output level, with higher effects during stronger solar irradiance. Similar trend has been observed by another Australian study on a regional level (Mahdavi, 2022) with a much higher estimate of about 20% rebound effect from rooftop PV installations. The rebound effects from both energy consumption improvements and installations of own energy production depend on how "energy-saturated" a consumer is. For instance, Chakravarty & Roy (2021) estimated that the rebound effect from energy efficient lighting coupled with solar PV could reach up to 200% in India, which was associated with meeting unmet energy needs of previously energy-poor households.

### Installing solar thermal heating

According to Chitnis et al. (2013), the rebound effect (income and embodied) from solar thermal heating applications in the UK was the largest (37%) among the seven improvement options explored. The pure income rebound effect from solar was estimated at around 12%, of which direct rebound was about 1.5%, the indirect effect of re-spending – about 11%. This means that economic savings generated by solar heating (minus capital costs) are re-spent on goods and services with higher energy footprints than reduced heating energy from conventional sources. The additional 25% was the embodied rebound (Chitnis et al., 2013). This heating option also seems to have significant emissions 'embodied' in the heating equipment itself.

### Home insulation

Home energy use can account for as much as 25%-30% of a person's total carbon footprint, depending on factors like heating and cooling requirements, the energy efficiency of appliances, and the source of electricity (Vita et al., 2019). House insulation is an effective sustainable lifestyle choice to reduce personal footprint. Passive housing (i.e. less than (15 kWh/($m^2$yr) could potentially save 6% of a household's carbon footprint by the need for reducing space heating by 40% (Vita et al., 2019). This could be achieved by renovating for better insulation (Mosenthal & Socks, 2015). Reducing the total living space (e.g. by living in smaller dwellings and/or cohabitating with someone) could further reduce the per capita energy consumption and the climate footprint. Chitnis et al. (2013) estimate that home insulation (different measures and applications) could reduce energy consumption between 1.7% and 7.3% in average UK homes.

However, rebound effects are rather likely to occur. After insulation improvements, households may opt to increase indoor temperatures because the cost of heating has effectively decreased. This can lead to higher energy consumption than initially anticipated. Also similar to other sustainable lifestyle options, there is a risk for indirect rebound effects. That is, the money saved from lower energy bills might be spent on other goods and services that have their own carbon footprints, such as travel or consumer goods.

The extent of rebounds can vary. A study by Sorell et al. (2009) suggests that the direct rebound effect for residential energy efficiency improvements, including insulation, can be around 20-30% (Sorrell et al., 2009). Chitnis et al. (2013) estimated that the rebound effects from home insulation measures alone could be ca. 12% and ca. 25% for direct and embodied rebound respectively (Chitnis et al., 2013).

However, distinguishing the extent of direct and indirect rebound effects from just insulation improvements is difficult. Most of available research is based on case studies, which implies a large variety of variables influencing the size and the distribution of rebounds. The variables may include energy prices, price and income elasticities, the size of savings, the cost structure of other goods and services, the characteristics of background energy systems, as well as personal environmental awareness and prevailing social norms (Gillingham et al., 2016).

### Choosing renewable electricity

Households can reduce their climate footprint by choosing less carbon intensive electricity contracts. However, this lifecycle option has implications for energy rebounds. Schleich et al. (2021) explored the impact of switching to green electricity tariffs on energy consumption among German households and reported a "renewable rebound effect". The direct electricity consumption among the green tariff households increased by around 8.5%. Interestingly, the effect was not temporary and persisted for at least four years. The study also suggested that green tariffs can also have a moral licensing effect (Schleich et al., 2021).

On the other hand, the adoption of green electricity might set new social norms that could encourage other sustainable behaviours (i.e. positive spillover effects). The adoption of green electricity has been found to induce social pressure on individuals to also adopt other sustainable practices, such as eating less meat, reducing heating temperature, water usage, composting, or choosing sustainable transportation options (Truelove et al., 2014). This clustering of sustainable behaviours can amplify the environmental benefits beyond the initial act of switching to green electricity.

### Reducing room temperature

Reducing room temperature is an effective measure to reduce personal climate footprint. It is not uncommon that households keep an unnecessarily high temperature indoors (Laakso et al., 2021). A comfortable room temperature can vary depending on individual preferences, the season, and the local climate, but it is generally considered to be around 20–22°C for most people. Lowering the temperature during the night or when a house is not occupied can also help saving energy.

Reducing energy consumption for heating generates economic savings and can also induce a moral licensing effect (Buhl & Acosta, 2016). Quantitative studies on this issue are scarce and often context-specific, so there is some ambiguity in the scale of the rebounds. In a case study of UK households reducing indoor temperatures by 1°C, Chitnis et al. (2013) estimated the rebound effect at 7%, while other heating and energy efficiency measures resulted in 12-13% rebounds. This is because other energy efficiency improvements require products, technologies and materials, which have emissions from energy and materials embodied in their life cycles. Chitnis et al. (2013) estimated that the total rebound effect including the embodied energy could be much higher (e.g. up to 67% for solar thermal). Given that lowering indoor temperature does not involve new technologies or materials implies that there are no rebounds due to the embodied energy footprints.

### Reducing living area

The average household size in the EU is shrinking due to a combination of demographic, social, and economic factors. According to Eurostat, the average EU household size was 2.2 persons in 2022[2]. The long-term trend is downwards due to several contributing factors, such as ageing population, high divorce rates, changing social norms and different economic aspects. It is not only that the size of households is decreasing but also there is an increasing number of solo-houses (Ala-Mantila et al., 2016).

Ivanova & Büchs (2020) calculated that average one-person households in the EU have a 9.2t-$CO_2$eq/cap energy intensity, which is about 17% to the EU's carbon and energy use. A significant

[2] Eurostat (2023). Household composition statistics. URL: https://ec.europa.eu/eurostat/statistics-explained/. Accessed 2023.09.29.

factor affecting consumption patterns is the size of one's living space, which inherently demands more energy, goods, and services for its maintenance. According to Vita et al. (2019), reducing the size of living areas not only diminishes the need for new construction but also lowers per capita energy requirements and the consumption of construction materials. Supporting this point, a study by Druckman & Jackson (2008) indicated that the carbon footprint per capita of a single-occupancy household is up to 75% larger than that of a four-person household.

However, households that reduce living space may experience lower utility bills and may choose more comfort and spend the savings on energy-intensive lifestyles, such as increased use of heating or cooling systems in the smaller space, thereby negating some of the energy savings. Furthermore, the financial benefits of downsizing, such as lower mortgage payments or rent, could influence the magnitude of the rebound effect. Quantitative estimates of rebound effects from households reducing the size of their living space are relatively scarce in the literature. Sorrell (2009) estimates the direct rebound effect for residential energy efficiency improvements at 20-30%. This study primarily focuses on energy efficiency technologies like insulation, but the same principle could apply to reducing living space where households reduce their living space, energy costs, and re-spending the savings either on consuming more energy for heating and lighting or purchasing other goods and services.

A study by Chitnis et al. (2014) estimates that the indirect rebound effect can range from 10-40% depending on the socioeconomic group. Money saved from reducing living space could be spent on other goods and services that have their own carbon footprints (Chitnis et al, 2014). However, the scale of indirect rebounds depends on income elasticity of households. Saunders (2008) suggests that the indirect rebound effect for energy-saving measures can be as high as 60% for lower-income households. The indirect rebounds will also have macroeconomic responses such as an increased overall economic activity, which in turn can increase overall energy consumption (Turner, 2013).

In addition, many different social factors and behavioural aspects like comfort and lifestyle choices can significantly influence the extent of the rebound effect (Galvin, 2015). The act of reducing living space could lead to a sense of moral satisfaction and moral licensing (Gillingham et al., 2016), making individuals feel they have "done their part" for the environment. This could result in reduced diligence in other areas of sustainable living.

### Sharing living space

Reduction of per capita living space can also be achieved by increasing cohabitation. This could include not only multi-generational families living under the same roof but also sharing living space with other individuals.

Reducing living space in this manner can also lower the per-person climate impact by opening up one's property for short-term sharing. Popular home-sharing platforms online, such as

Airbnb, HomeStay, Booking.com, FlipKey, Wimdu, and many others, offer various options for travellers and homeowners alike. These platforms allow homeowners to rent out their homes, rooms, or other living spaces to guests for short-term stays. Some estimates suggest that peer-to-peer home sharing has about a 50% lower carbon footprint compared to similar-sized accommodation at a midscale hotel (Rademaekers et al., 2017). Peer-to-peer sharing also offers other environmental benefits, as they are relatively less resource-intensive compared to hotels (Zervas et al., 2016).

On the other hand, home sharing induces several rebound and unintended effects. Although it has a substitution effect on traditional lodging options, it expands the overall accommodation market, potentially leading to increased travel (Dogru et al., 2019). According to Zervas et al. (2016), home sharing has led to at least a 2% increase in overall travel and tourism. Furthermore, there are indirect environmental implications of increased local spending due to home-sharing platforms, including a potential rise in carbon emissions from increased consumption by local visitors (Gössling & Michael Hall, 2019).

## Nutrition

Overall, comparing the various studies we reviewed proved to be challenging. This challenge arises primarily because the term 'sustainable diet' is defined differently across these studies. Additionally, researchers employ distinct boundaries and parameters in their calculations and considerations. However, based on the available literature, it seems that changes in dietary habits result in a relatively minor net impact on energy consumption and greenhouse gas (GHG) emissions, especially when compared to other consumption areas such as mobility and housing (Grabs, 2015).

Reducing food waste and altering dietary habits have been the focus of numerous studies examining their potential rebound effects. The magnitude of these effects varies significantly across studies. For instance, the rebound effect of reducing food waste ranges from 23%-59% (Salemdeeb et al., 2017), 57% (Hagedorn & Wilts, 2019), 59% (Druckman et al., 2011), 77% (Chitnis et al., 2014), to as high as 68%-100% (Bjelle et al., 2018). One key factor influencing these outcomes is the re-spending behaviour. Savings from avoiding food waste, when spent on energy-intensive categories such as air travel or heating, can negate the environmental benefits (Martinez-Sanchez et al., 2016). However, WRAP (2014) observes that people often re-spend these savings on higher quality and cost food items, such as local produce or better quality meat.

Changes in meat consumption also exhibit significant rebound effects. Reducing meat consumption at home and in restaurants by 50% could result in a 25% rebound effect (Wood et al., 2018). A study on vegetarianism by Grabs (2015) found rebound effects ranging from 76-130% for energy use and 25-88% for greenhouse gas emissions. Similarly, a shift to a diet with less meat and dairy showed a 140% rebound effect (Alfredsson, 2004). Interestingly, higher-income groups tend to show lower rebound effects, whereas lower-income groups exhibit

higher effects due to their tendency to spend savings on more environmentally intensive goods (Lenzen & Dey, 2002).

The concept of moral licensing was explored in a study by Dreijerink et al. (2021), which found that some Dutch consumers who follow a vegetarian diet occasionally revert to less sustainable choices, such as eating meat or considering the purchase of a less fuel-efficient car. Contrary to these findings, Andersson & Nässén (2023) argue that adopting a vegan diet can have a positive spillover effect on other consumption domains due to the pro-environmental values held by vegans. This is supported by an earlier study that found 'green' consumers are likely to re-spend on organic products (Carlsson-Kanyama et al., 2005).

Locally produced or organic foodstuffs are usually more expensive, which may reduce the indirect effects of re-spending the savings achieved from, e.g. food waste prevention. A Norwegian study by Bjelle et al. (2018) estimated that an organic green diet could lead even to negative GHG rebound effects (that is absolute reduction of GHG from consumption) ranging between -47% (among households who avoid re-spending on goods and services with high emission intensities) and -68% (assuming households change their spending patterns towards similar re-spending as households with higher income). By adopting other measures like consuming more expensive organic and locally produced products and composting, the rebound effects could be even more negative and between -91%-134%.

**Avoid food waste at home**

Reducing food waste has the largest potential to reduce GHG emissions compared to other options, such as buying a fuel-efficient car. However, avoidance or prevention of food waste in households saves money. It can thus lead to an economic rebound effect when these savings are spent on food products and services or other consumption categories (Binswanger, 2001). If savings from avoidance of food waste go into energy-intensive categories, such as air travel and heating of space, the environmental benefits of avoiding food waste can be completely negated (Martinez-Sanchez et al., 2016).

For instance, Chitnis et al. (2014) found it to reach up to 77% and be the largest rebound among 10 different lifestyle measures for reducing GHG emissions from UK households. These also included different improvements of house insulation, reducing car travel, more fuel efficient vehicles, and more energy efficient lighting options. A German study by Hagedorn & Wilts (2019) found that food prevention results in a 57% rebound due to re-spending. In a Norwegian study by Bjelle et al. (2018), eliminating food waste may lead to between 68% and 100% rebound effects from re-spending the savings.

It is usually hard to estimate what people re-spend their savings on. In WRAP (2014), an observation was made that when reducing food waste, people tend to spend 50% of their savings on up-trade of foods, i.e., purchasing food of higher quality and cost, such as buying local food, better quality meat or switching to higher-cost food categories. A study by

Salemdeeb et al. (2017) used this observation in developing their scenarios. Their overall results show rebound effects from avoiding food waste to be in the range of 23%-59%, where the latter comes from re-spending on GHG-intensive categories, such as fuel and flying. The 23% rebound effects are associated with re-spending on education, communication and real estate services. Still another study showed that households using a peer-to-peer platform that collects and redistributes food (to avoid food waste) showed 83% of the environmental rebound effect due to households re-spending money saved on other products and services (Meshulam et al., 2022).

Studies suggest, therefore, that reducing food waste through food prevention, such as better planning of food shopping and meals, avoiding cooking too much food and reusing leftovers, should also be accompanied by using the generated savings on low-impact consumption categories (Martinez-Sanchez et al., 2016). Such low-impact categories are "health, education and culture", as suggested by Albizzati et al. (2022), who advocate policy support for consumption categories that are not only low or negligible in terms of their environmental impacts but also have positive social impacts.

**Reduce animal-based products in the diet**

Many studies evaluate the environmental impacts of different types of 'green diets' where a certain meat reduction is modelled. For example, a study by Tukker et al. (2011) modelled three scenarios, where two had lower meat consumption. The study demonstrated that even such a modest change as substituting red meat by 40% with chicken, seafood and cereals could lead to an 8% reduction in impacts associated with food consumption. The same result is arrived at even if the direct rebounds - income effects – are taken into calculation.

**Switch to a vegan diet**

A vegan diet is usually defined as a diet without meat, fish, eggs and dairy products. A study by Andersson & Nässén (2023) shows that a vegan diet leads to lower $CO_2$eq/cap/year from food compared to a typical diet, as could be expected, but that it also has a positive spillover effect on other consumption domains, thereby reducing impacts elsewhere. This is explained by vegans' strong pro-environmental values that prevent them from re-spending in categories with high environmental impacts.

**Switch to a vegetarian diet**

A vegetarian diet is usually defined as a diet without meat and fish. A few studies investigate the rebound effects of a vegetarian diet (Grabs, 2015). A study with a hypothetical scenario of a reduction of meat consumption at home (50%) and in restaurants (50%) by Europeans arrived at a 25% rebound effect (Wood et al., 2018). These rebound effects were caused by the increased demand for non-meat products and increased consumption of other products triggered by savings from the no-meat diet. A study of vegetarianism by Grabs (2015) shows

significant rebound effects: 76-130% - for energy use and 25-88% - for GHG emissions. Higher-income groups show lower rebound effects – 76% for energy and 25% for GHG emissions, and lower-income groups have higher rebound effects, 130% and 88%, respectively because they tend to spend savings on more environmentally intensive goods. An interview study by Dreijerink et al. (2021) explored awareness about the moral licensing effects of Dutch consumers who already follow a vegetarian diet and those who do not. For vegetarians, following this diet became habitual, so little effort was required from them. Still, for some of them, efforts were required concerning the social context, e.g., ensuring that there were vegetarian options when they were eating out. But the highest effort was for those who were not vegetarian. Switching to a vegetarian diet would require abandoning eating meat and fish, the taste and texture of which they liked. Also, learning new recipes and finding new products and substitutes was mentioned as additional effort. Most of the interviewees disagreed with the suggestion that they would follow moral licensing after they have become vegetarian. However, 5 out of 26 interviewed consumers offered examples of moral licensing behaviour, ranging from eating meat after several days of following a vegetarian diet (direct rebound) to having fewer hesitations when considering buying a less fuel-efficient car (indirect rebound).

**Eat only organic vegetables and fruit**

Our search strings yielded just one article that specifically mentioned an organic-based diet and estimated the associated rebound effects. According to Bjelle et al. (2018), eating an organic green diet leads to a negative rebound effect between -47% and -68% (i.e. absolute reduction of GHG from consumption). When other measures are added, such as local products and composting, the rebound effects can be between -91% and -134%, again due to the high costs of implementing both of these actions.

Organic food is often mentioned as an example of a re-spending category of goods that helps avoid rebound effects due to higher prices of organic products (Hertwich, 2005). So, when efficiency measures lead to cost savings, the savings should be spent on higher-quality goods with lower sustainability impacts. Studies show that pro-environmental norms and values are essential in making these decisions (Andersson & Nässén, 2023). This supports an earlier study where the assumption was that 'green' consumers would re-spend on organic products (Carlsson-Kanyama et al., 2005).

**Eat only seasonal vegetables and fruit**

Our searches did not find sources that would explicitly calculate the rebound effects of eating seasonal vegetables and fruit. This might be due to the difficulty of defining what seasonal means in terms of seasonal local or seasonal global foods. The difference between these two categories of seasonal food has implications for the environmental impact and associated rebound effects (Schanes et al., 2016). Seasonal global products might not necessarily have larger environmental impacts; it depends on the production methods both in agriculture and food processing (Brooks et al., 2011).

### Locally produced food

Our search did not find any studies where the rebound effects of locally produced food were calculated or estimated. A general comment is that rebound effects will be linked to the prices of locally produced food. In some countries, they will be lower than imported goods; in other countries, such as Sweden, they will be typically higher than imported food products. Overall, locally produced food cannot be equated with sustainable food as it might not be the best option from a food security or environmental point of view (Stein & Santini, 2022).

### Drink tap water in place of bottled water or manufactured drinks

No specific studies have been identified investigating the rebound effects of switching from drinking tap water to bottled water or manufactured drinks, probably due to low spending on these items in the household budget. Again, following the logic of rebounds, money would likely be saved from this action that could be re-spent on other goods and services that could have a higher or lower impact than bottled water.

## Leisure

Research on the rebound effects in the domain of holidays and leisure mobility largely converges with existing mobility studies. Carlsson-Kanyama et al. (2021) offer a nuanced examination of train holidays in comparison to driving, flying, or staycations. The choices result in a shift in GHG effects, but the savings, or lack thereof, depend on the assumptions made.

Wood et al. (2018) explored the rebound effects in the apparel and textile sector, uncovering a high rebound rate of 75%. This is attributed to the sector's low carbon intensity compared to other consumption categories where spending subsequently shifts. Kawajiri et al. (2015), however, posit that opting for higher quality and more expensive goods, such as clothing, could mitigate both climate impacts and rebound effects.

Makov & Font Vivanco (2018) investigated the rebound effects associated with smartphone reuse, identifying a range of rebound effects to be between 27% and 46%, with an average effect of 29%. The primary driver of this rebound is the re-spending of savings, predominantly on food, non-durable goods, and transport. The authors also highlight that purchasing a second-hand phone does not serve as a direct substitute for buying new, corroborating the findings of Ottelin et al. (2017), who noted that repair activities are associated with an increased material footprint.

It is noteworthy that reducing flying, a high-impact lifestyle choice, is likely to have limited significant rebounds and may even yield positive spillover effects. Similarly, buying fewer clothes and shoes of higher quality may result in negative rebound effects due to their high

price and lower impacts relative to other consumption categories.

### Small (er) pets

There were no previous studies found considering this option and rebound effects.

### Pet food with a smaller carbon footprint

There were no previous studies considering this option. However, in previous citizen workshops participants indicated this would likely be more expensive, which indicates a possible negative rebound effect via income effect but still a possible moral licensing effect when it comes to pets in general.

### Vacation by train instead of plane

Kim et al. (2020) indicate a reason that planes are often taken for vacations is to maximise time use for vacation. They do not consider substitution of trains for planes but their study implies that this substitution would take more time, which can also be a factor limiting rebound.

### Reduce driving associated with holidays or leisure time

The rebound effect of this option largely depends on the scenario. Most mobility studies reviewed do not assume mobility for leisure decreased overall but rather it is substituted by other mobility modes, e.g. by plane or train. Carlsson-Kanyama et al. (2021) consider train holidays, versus driving, versus flying versus staycations. The choices result in a shift in GHG effects, but the savings, or lack thereof, depends on the assumptions made.

### Flying less

Many studies noted the need to address flying as a potential rebound area from other domains, but few are specific in either how to reduce flying or the effects of reducing flying. Figge et al. (2014) consider one of the effects of reducing flying to be a lower load factor on planes, resulting in higher prices and eventual cancellation of routes -i.e. a reduction in demand leads to further reduction in demand.

Andersson & Nässén (2023) address the question of flying and rebound more directly. Looking at empirical findings from a survey of 715 Swedish users of a carbon calculator app (and thus, an environmentally interested sample), they found only a small (2%) rebound effect of reducing long distance travel through not flying through re-spending in the housing domain. The authors were surprised that the lack of flying did not lead to more driving, as expected from the modelling using the marginal redirected spending assumption. In fact, the authors found evidence of positive spillover effects, e.g. in further reductions of short distance travel (-8 kg $CO_2$/cap/year), food (-29 kg $CO_2$/cap/year), and other categories (-117 kg $CO_2$/cap/year). It is

important to note no flying was also the most significant action they examined in terms of total reduction of climate impacts and the rebound very limited by comparison (1520 kg $CO_2$eq/cap/year reduced with a 177 kg $CO_2$/cap/year rebound in housing)

As mentioned, the focus in literature was on flying as the rebound behaviour for other actions, e.g., going car-free. Ottelin et al. (2017) find that flying for leisure is often a rebound action associated with car-free lifestyles and suggest the need to target this action in particular while Vita et al. (2019) assume that savings from cycling are re-spent on flying, resulting in carbon reductions being offset by increased from flying. Similarly, Sorrell et al. (2020) also find high potential for flying to be a rebound behaviour (in response to energy sufficiency related behaviour changes); moreover, noting that even people with strong environmental attitudes may overlook flying as a potential rebound undermining other their actions to lower their carbon footprint. Czepkiewicz et al. (2018) also note that flying is positively correlated with access to an airport. Similarly, the propensity to take a train is influenced by access to train stations. Finally, Große et al. (2019) also find flying as a potential rebound action associated with urban and smaller living spaces.

### Buying fewer clothes and shoes

Wood et al. (2017) investigated reductions in demand for apparel and textiles. They assume savings are re-spent on other goods and services. Interestingly, they find a high (75%) rebound due to the low carbon intensity of the clothing sector compared to other consumption categories where consumption is shifted. However, reduction of clothing and shoes was not explicit in the studies reviewed as many studies only dealt with sufficiency strategies more generally. Kawajiri et al. (2015) suggest that buying higher quality and more expensive goods such as clothing could actually reduce both climate impacts and decrease rebound effects.

## Other behaviour changes

### Ecological and ethical personal investments

Claudelin et al. (2020) consider the possible rebound effects of different cases of investments. They find that investments with the intention for high-emission consumption later (e.g., long distance vacation flights) have the most potential for rebound effects. However, the intention of the investment (i.e., what any monetary returns will be used for), the goal of the savings or investment (e.g., that the savings investment itself is used to support a project to reduce emissions), and lastly the use any returns on the investment is not used for additional high emission consumption but reinvested in low carbon activities/projects. They also find that reinvesting saved money from one low carbon lifestyle change (e.g., reduction of meat or flights) into a low-carbon investment (e.g., a solar energy or carbon sequestration project – what they term "impact investing") can be an effective measure to not only reduce rebound, but to increase the low-carbon impact of the first action (e.g., a negative rebound effect).

### Reduced working hours and spending

Wiedenhofer et al. (2018) considered that income remains a driver of overall carbon footprints and summarise previous literature for three potential consequences of reduced working hours:

1. Less work with less income can reduce carbon footprints due to reduced spending and shifts in consumption patterns
2. More time on well-being activities including community building. Studies in Germany and Australia (cited in Wiedenhofer et al 2018) show that more discretionary time is positively related to low-carbon care and community activities.
3. Sharing working time with others to reduce unemployment (though this depends on many factors whether it reduces impact overall). Sahakian (2015) also notes the co-benefits to work sharing.

While the possibility to rebound with this option is present, the likelihood is lessened in the cases where income is reduced. Indeed, reducing working time is promoted as a possible mechanism to reduce rebound in itself (discussed later in this report).

### Spend more money on non-consumptive activities instead of buying goods

While there were no studies looking at rebound of this option in particular, this was considered as a possible measure for addressing rebound by some, e.g., Wiedenhofer et al. (2018). Albizzati et al. (2022) further specify that such activities would mainly be related to health, education and cultural activities.

### Donate money to environmental causes or organisations

Claudelin et al. (2020) find that reinvesting saved money from one low carbon lifestyle change (e.g., reduction of meat or flights) into a low-carbon investment (e.g., a solar energy or carbon sequestration project – i.e., "impact investing") can be an effective measure to reduce rebound. It has the added benefit of increasing the GHG mitigation potential of the first action (e.g., a negative rebound effect).

## BROADENED PERSPECTIVES ON REBOUND EFFECTS

Despite the undeniable importance of rebound effects as they have been studied thus far, a narrow conceptualisation of such effects does not address the complexity of consequences of low-carbon behaviour changes (Font Vivanco et al., 2022). As such, they are insufficient to understand the complexity of potential unintended consequences resulting from shifts towards 1.5° lifestyles. Furthermore, they provide an insufficient picture to support the development and implementation of short- and long-term measures to mitigate negative consequences from transitioning to 1.5° lifestyles. For this to be successful and acceptable to individuals, it is essential to gain a better understanding of the breadth and complexity of different direct and indirect rebound effects from low-carbon behaviour changes, and also the

complexity of the drivers that consider not only the individual consumer, but the consumer as a part of a larger social and economic system (Font Vivanco et al., 2022).

Unsurprisingly, a broadening of the conceptualisation of rebound effects also results in boundaries of the concept to become "fuzzy". It also brings about some disagreement regarding what to include in a rebound discussion without watering down the term to a degree that it is meaningless and thus useless. While acknowledging this challenge, we do not consider it problematic to our work; indeed, we consider this project to contribute to its resolution.

Our systematic literature review found a limited but useful selection of articles that discuss a broader variety of possible rebound effects. Börjesson Rivera et al. (2014), discussing the consequences of innovation in ICT, provide a comprehensive list of rebounds beyond direct and indirect economic rebound effects, such as: 'substitution', 'rematerialisation effects', 'induction', 'economy-wide rebound effects', 'time rebound', 'space rebound', 'learning about production and consumption', 'scale effects and learning in production and consumption', 'changed practices', and 'transformational rebound effects'. We will not discuss each of these possible terms here but use this case to illustrate the potential breadth the discussion can develop into and thus to draw the boundary.

For instance, Seebauer (2018) focuses on the psychology of rebounding and explores 'moral licensing', 'compensatory behaviour', and 'spillover' as psychological rebound effects. Depending on individual traits, these effects can play out differently and moderate the size and direction of rebounds materialising. Seebauer concludes that across factors compared, the intensity and direction of rebound effects depend on pro-environmental values and the behavioural mindset of the individual.

Hertwich (2005), coming from an Industrial Ecology perspective, also argues that a focus on economic rebound effects is too narrow and that any analysis of rebounds should be extended to both behavioural and systems responses. He suggests that the term ´ripple effects´ might be more suitable for conceptualising rebound effects. Furthermore, these effects may occur in many different forms, and while they may be unintended, they are not always negative (for example, positive health effects or better social health).

## Considering ripple effects

Laurenti et al. (2016b) build upon Hertwich's suggestion of ripple effects to map and show the ripple effects of the global economic system and consumption more generally. They map the macro-level rebound effect driven by improvements in efficiencies that in turn drive down costs and prices, leading to increased consumption. They consider the socially and environmentally negative impacts, e.g. depletion of natural resources and polluting activities in product chains that in turn cause negative impacts to humans and ecosystems. Basically, they consider all externalities, i.e. consequences of an economic activity that are not reflected

in market prices, part of the overall as ripple effects of consumption activities.

Negative environmental and social impacts also exist in the production chains for many of the low-carbon technologies that underpin some of the lifestyle options. While renewable energy technologies such as wind and solar have lower environmental impacts compared to conventional energy system technologies, they still have substantial environmental impacts, in particular related to the materials needed and embodied energy, which need to be considered (UNEP, 2016). Similarly, mining and processing of materials for the batteries for electric vehicles are not without environmental impacts, though again, the total environmental impacts for electric vehicles is often less than conventional vehicles (Temporelli et al., 2020). In particular, the need to consider potential negative biodiversity impacts of developing low-carbon technologies has been highlighted (Santangeli et al., 2016). While this report focuses on climate impacts, it is important to note that reducing climate impacts is only one part of reducing total environmental impacts and climate change is only one of the planetary boundaries that needs to be urgently addressed. Addressing climate change issues in isolation of other environmental impacts can result in trade-offs between impacts or leave issues related to material use unaddressed (see Wiedmann et al., 2020).

Taking into account ripple effects is also important when considering strategies to reduce rebound effects, as these strategies will have their own consequences beyond reducing rebound. For example, reducing working time has been suggested as a key strategy for reducing consumption rebounds. This action can also have positive consequences for people in terms of improving work-life balance and the overall quality of life. For example, French employees experienced a better quality of life when their work week was cut to 35 hours (Kasser & Sheldon, 2009). A Swedish study cited by Nässén & Larsson (2015) also found that employees who worked 6-hour days for 18 months reported enhanced life satisfaction, health, and a more balanced division of household chores. Similarly, other studies found a clear link between reduced work time and improved life satisfaction and health (Shao, 2022).

However, there are also negative consequences to consider. Reduced work time can pose a financial risk to low-income groups (Druckman & Jackson, 2016). A reduced income can also result in loss of social recognition and status, particularly in specific cultural contexts, e.g., Switzerland (Sahakian & Rossier, 2022) and Germany. Buhl & Acosta (2016, p. 274) specify that while full-time employment in Germany is associated with status and social recognition, "*part-time work leads to a loss of economic and symbolic capital, i.e., a loss of income and occupational status*". Gender inequalities can also be exacerbated, especially in high-income countries with weaker family policies (Fagan et al., 2018; Sahakian & Rossier, 2022). Moreover, long-term economic insecurity can be a concern, especially for women during family care periods (Comolli et al., 2021; Carmichael & Ercolani, 2016).

Although reduced worktime has a potential to lower carbon emissions of consumption, it depends on how the freed-up time is spent (Druckman et al., 2012). There is a risk of a "time rebound" effect, where people may engage in more carbon-intensive activities (Jalas, 2002). Additionally, leisure activities can easily be energy- and consumption-intensive, and more free

time could lead to increased resource consumption (Kallis et al., 2013).

Studying ripple effects is complex and highly dependent on what is searched for. It can be difficult to study ripple effects through literature review, as they need to be identified before they can be searched for. Rebound effects are an identified ripple effect, but only part of the effects of the lifestyle options explored above. For this reason, it is suggested that first a mapping of potential effects is needed (Laurenti, 2016b) that can then guide further exploration of ripple effects. This was the starting point for the co-creation workshop component of this research.

# CO-CREATION WORKSHOPS

For empirical data collection, we relied on a series of five so-called co-creation workshops. These workshops were planned by Lund University (ULUND) in January 2023 and implemented by the five case country partners (adelphi, GDI, GL, UDC, ULUND) for each country respectively. The workshops were held in the five case countries in May and June 2023. In the following, we elaborate on the logic of the chosen method, as well as how data was collected and analysed.

## WORKSHOP APPROACH

### Studying the breadth of potential rebound effects

In WP4, we had two objectives with conducting co-creation workshops in the five case countries; first - to address the existence and understanding of various rebounds, second - to explore the social risks associated with these rebounds. While much research on rebounds is rather narrow in its focus on financial effects and consequences when studying rebound effects of behaviour changes, to better understand the (unintended and unforeseen) outcomes of shifts towards low-carbon lifestyles, and the consequential rebound effects, a broader view on effects and consequences of such lifestyle changes seemed preferable (Font Vivanco et al., 2022). Here we define social risks as all undesirable ripple effects that might occur when implementing lifestyle changes.

With workshops, we have chosen a qualitative research method, despite many research studies on rebound effects are of quantitative nature. The qualitative approach allows capturing psychological effects and include time rebounds into any analysis of the overall, long-term impact of low-carbon behaviour changes, as these can be of great significance when trying to understand both the immediate and long-term lifestyle changes stemming from how people spend their time (not only their money), and what they desire (e.g., Seebauer, 2018). Hertwich (2005) talks about 'ripple effects', rather than 'rebound effects', and stresses that they can be unintentional, time-delayed, and both positive and negative (e.g., positive health effects, but negative income effects). Studying ripple effects, in turn, relies on identifying factors, key assumptions, and relationships between these factors, which requires a qualitative approach that can later be the basis of, or inform, quantitative approaches (Laurenti et al., 2016a).

### Focusing on pioneers of 1.5° behaviour changes

As stated above, with this research we aim to develop a broad and detailed understanding of the breath of ripple effects caused by low-carbon lifestyle choices, in order to better understand the complexity of indirect effects connected to behaviour changes. The project interviewed '*pioneers*' of low-carbon lifestyles, and engaged '*average citizens*' in workshops to test acceptance for various sustainable behaviour changes. From this experience, and

drawing from existing knowledge about the challenges for people to imagine complex, indirect outcomes (e.g. Kahneman, 2011; Loewenstein et al., 2003), we judged that a lived experience is the best source of information.

For our workshops we tried to choose individuals who live in a way that contradicts the dominant narrative in literature on rebound effects being a real and significant problem to achieving low-carbon lifestyles. Although these individuals are still a clear minority in society, they have acquired substantial and comprehensive understanding of how lifestyle actions can be taken to diminish rebounds, and of what social risks come with such actions. Empirically analysing effects with individuals who have already implemented behaviour changes provides a valuable insight into the importance of different theoretical perspectives on rebound effects (Andersson & Nässén, 2023; Reimers et al., 2021).

For the co-creation workshops in the five case countries, we define *'pioneers'* as citizens that have managed to achieve a substantial reduction in carbon emissions based on voluntary actions. With consideration for prior research within the EU 1.5° Lifestyle project and to achieve coherence across the project, we rely on the WP2 conceptualisations of low-carbon lifestyle choices. To keep the workshop design manageable, we stipulated that an individual qualifies as 'pioneer' for the co-creation workshops if he/she have implemented at least one, and ideally more, of the behavioural changes that WP1 calculated as having the most significant carbon reduction potential.

# DATA COLLECTION & ANALYSIS

## Workshop design

We refer to the conducted workshops as co-created, as we followed a process that combined real-life experience from citizens (the "pioneers") and scientific knowledge (from the literature review) in a guided process (the workshop) to apply a scientific method (Causal Loop Diagrams - CLDs) to the solution of academically grounded research questions. The aim of this co-creation process is to shorten the distance between data collection (from the pioneers) and data analysis (done by researchers) to - at least partly - take place with the individuals the data is collected from in the room and thus being able to validate the results.

Causal Loop Diagrams (CLDS) are tools used to illustrate and understand complex cascades of events and visualise factors, causal links, and effects in a system (Laurenti et al., 2016b) and help developing solutions (Laurenti et al., 2016a). For us, they are of particular interest due to their suitability to facilitate 'group model building', an exercise that Watz et al. (2020) suggest as useful to minimise risks for rebound effects in planning and decision-making.

To make a co-creation process of the workshops feasible, we modified the CLD approach and to focus on 'Cause-Effect Diagrams', or CEDs. While feedback loops were still present in the models, they were not the focus, which emphasised causes and effects from the citizen

perspectives. The loops involving the climate impact (i.e. the Greenhouse Gas (GHG) footprint of participants) was the only larger system level loop in focus while other loops were more on the individual level (i.e. there could be a feedback loop where participants identified factors that reinforced certain behaviours). The workshop participants were thus co-creators in the scientific method constructing the CEDs, which we present as results later in this report (see Workshop Results).

To build these CEDs, and to inform the focus group discussions, we drew from our systematic literature review, as well as earlier results from the EU 1.5° Lifestyles project. This included primarily the quantification of low-carbon lifestyle choices completed in WP1, interviews with pioneers (WP2), and workshops with average citizens about preferences and scepticism towards a battery of possible low-carbon lifestyle changes (WP3).

For our WP4 workshops, we limited the focus to four high-impact behaviour changes: (1) give up flying, (2) give up car ownership, (3) give up meat, and (4) reduce living space to <30m2/person. This narrowed down focus helped facilitate more in-depth discussions on each behaviour change. We deemed it justifiable also because of the dominant role (Andersson & Nässén, 2023) these four behaviour changes have in low-carbon lifestyles.

The workshop was built up around two rounds of CED exercises, in which participants were asked to help us complete the diagrams with information about causes of their behaviour changes, and effects of these behaviour changes, in relation to income, time use, and other indirect effects.

Apart from the CED exercises, the workshops also had an initial element of individual reflection at the beginning of each exercise, and a focus group discussion after each exercise. The individual reflections served as a way to trigger participants' memories and reflections, so that they more eloquently were able to report and discuss their lived experience. For that purpose, they were asked to answer four questions in writing on two (one in the morning, one in the afternoon) pre-printed 'reflection sheets' in silence. The four reflection questions were:

1. How did I avoid rebounding from this [i.e. one of the four chosen behaviour changes] low-carbon behaviour change?
2. How did I rebound from this low-carbon behaviour change?
3. What were the negative effects of this low-carbon behaviour change?
4. How did I deal with these negative effects?

All individual reflection sheets were collected after the exercise to be used for analysis. In our analysis these written personal statements were treated equal to spoken direct quotes from the participants.

At the end of each session, participants joined larger discussion groups (the four groups were merged into two discussion groups) to reflect about what they had just produced in their respective CEDs. The discussion groups were composed of members of all four prior workshop

groups, as these groups were intended to allow for more general observations and reflections that are similar or distinctly different across the studied behaviour changes.

## Participant recruitment

In total, 84 'pioneers' participated in the five workshops, divided up into five country workshops (Germany 12, Hungary 17, Latvia 19, Spain 19, Sweden 17). Participants were recruited with the help of a screening survey. The aim was for participants to reflect a variety of backgrounds (age, occupation, income, environmental awareness). Concrete recruitment criteria were: max 5 people over 65 years of age, max 5 full-time students, max 5 unemployed people, and at least 50% make lifestyle changes for environmental reasons. Importantly, they all also had to fulfil the 'pioneer criteria' to be eligible for participation:

*Implementation of at least two, but ideally several behaviour changes from a short-list of the most-impactful lifestyle changes identified in prior research of the 1.5° Lifestyles project.*

This short-list of the most impactful lifestyle changes (Table 2) was compiled from data calculated in WP1 of the EU 1.5° Lifestyle Project.

Table 2: Short-list of behaviour changes and adaptation for pre-survey

| Behaviour change (not in order of impact) | Pre-survey question |
|---|---|
| Give up your car and walk or cycle instead. | I have given up my car. |
| Replace your car with the use of public transport. | |
| Carpool | |
| Switch from using a conventional car to an electric car. | I have switched to an electric car. |
| Give up excess square metres. | I have moved to a smaller home. (Please count m2 per person in the household, not total m2.) |
| Drive less for your hobbies and leisure. | I drive less. (Driving as part of your job does not count.) |
| Reduce the driving associated with your holidays. | |
| Choose shared housing. | I live with more people now. |
| Insulate your house. | My home has been insulated to save energy. |

| | |
|---|---|
| Lower the room temperature of your home. | I keep my indoor temperature at least 2° colder in the heating season.<br>*I keep my indoor temperature at least 2° warmer during the cooling season (air conditioning).** |
| Reduce energy use by monitoring your consumption. | I have reduced my energy consumption through better monitoring. |
| Replace your heating system with a biomass boiler. | My old heating system was replaced with a heat pump or a biomass heater. |
| Replace your heating system with a heat pump. | |
| When moving house, move closer to your workplace. | I have a shorter commute to work today. |
| Favour working at a home office. | I used to commute to work, but now I instead work from home. |
| Reduce animal-based products in your diet. | I eat fewer animal products. |
| Switch to a vegan diet. | I have become a vegetarian or vegan. |
| Fly less for leisure and holidays. | I fly less. (Flying as part of your job does not count.) |

*Relevant for climates where cooling is required in summer.

Beyond having implemented behaviour changes of the short-list, we sought participants who had implemented at least two of four behaviour changes that were modelled in the 'Cause and Effect Diagrams' (CEDs) for the workshops, as every participant was allocated to a group that worked with one of these CEDs. The four CED-behaviours are:

- *I have become vegetarian or vegan.*
- *I have given up my car.*
- *I have stopped flying for leisure.*
- *I reduced my living space (30m2/per person or less).*

## Documentation & analysis

The workshop results were captured as photos, audio recordings, written evidence, and note taking by moderators and facilitators. All documentation followed the EU's GDPR regulations and was done with the consent of the participants.

All written documentation was conducted in templates developed by the authors and translated into English by case country partners for analysis. The whole documentation we relied on in the analysis of the workshops consisted of:

- 84 Individual Reflection Notes[3],

[3] Not every participant followed the instructions for the individual reflection notes, meaning that some did not provide answers to all four reflection questions (see Table 10 in Appendix)

- 5 x 4 Cause and Effect Diagrams which were documented visually,
- 5 x 8 Discussion notes from the CEDs,
- 5 x 2 Discussion notes from the focus groups.

The analysis was guided by the research aims of WP4:

- To identify and understand potential mitigation strategies for rebound effects,
- To identify and understand potential mitigation measures for social risks associated to low-carbon lifestyles,
- To inform the development of short-term and long-term strategies to reduce risk and mitigate rebound effects and avoid social costs on a societal level.

For the analysis, text documentation from all 5 workshops (individual reflection notes, discussion notes from CED exercise and focus groups) were compiled, reviewed and translated by all the case country partners. The documentation was then uploaded to the qualitative data analysis software NVivo 14, where 3 researchers from Lund University worked collaboratively in coding the material in an iterative process.

The coding process started by first reading through all the material in NVivo, upon which we developed an initial coding structure. Based on this initial coding structure, we analysed all the individual reflection notes by lifestyle option, where each researcher individually analysed 1-2 lifestyle options each. During this step, we collectively developed our codebook, and each researcher independently added and edited the codes and their properties in inductive-deductive iterations. After this, we tested our preliminary codebook on the remaining uncoded discussion notes. Weekly meetings were held to discuss the themes and each researcher edited and refined the codebook until the thematic structure represented all the topics and questions that the participants had discussed during the workshop.

After all workshop material was coded, we finalised the coding process and ensured consistent coding by collectively reviewing the codebook. In this last step we also made a final deductive iteration to our codes, where we clustered and/or renamed some subcodes, to correspond with the themes specific to the lifestyle options. See Table 9 in Appendix for final code structure and the key themes that emerged from these.

A total of 6 reflection notes was coded separately to the main code structure used for the group of pioneers, as it was discovered during the analysis that these 6 participants did not match our criteria of implementing at least two of our four high-impact behaviour changes (see Table 10 in Appendix). For example, they still flew even though reporting upon recruitment that they had stopped flying, or never had a driver's licence to begin with and hence had not made the lifestyle changes relevant for this study.

## Limitations

As explained, we have good reason to have chosen a qualitative approach for this study. However, this choice entails that our data can only serve to provide an initial insight into a complex phenomenon. Our data is able to shed light and provide explanations for observed challenges in achieving low-carbon lifestyles across the EU, as well as reveal possible paths to overcoming some of the challenges hindering low-carbon lifestyle adoption across the EU. It can serve as a first step in exploring the complex question of indirect effects from low-carbon lifestyle changes. Once a sufficient understanding has been reached, it can be studied quantitatively so as to achieve statistically valid answers (Tierney & Clemens, 2011).

Qualitative research is also more exposed to bias and subjectivity in interpretation of results by the researcher(s)(Tierney & Clemens, 2011). Even a structured analysis of qualitative data is prone to subjective interpretation, and as such is influenced by researchers' personal experience, cultural background and worldviews. We acknowledge that qualitative research can never be fully objective. However, involving several researchers in the analysis and interpretation of results can reduce subjectivity. Indeed, the 1.5° Lifestyle project comprises a large pool of experienced researchers from different cultures and backgrounds. Also the core workshop design team included four researchers with diverse backgrounds.

To be able to clearly identify 'pioneers', we decided to only choose individuals who had implemented the four behaviour changes completely, e.g. to give up a personal car. This of course simplifies reality, where a 'pioneer' can very well own a car, but reduce its use to a necessary minimum, and still achieve a big carbon emissions reduction. This meant that our sample was skewed towards a certain type of 'pioneer'-behaviour, while it excluded other types of 'pioneer'-lifestyle.

# WORKSHOP RESULTS

In this section, we summarise the workshop results. First, we present an overview of all the effects reported by participants in the workshops, followed by the stated reasons for their lifestyle change of either giving up flying, giving up car ownership, giving up meat or reducing living space. Second, we outline the undesirable and desirable ripple effects experienced by the participants as a result of the lifestyle change. Third, we describe what strategies the participants have employed to mitigate rebound effects and to deal with the undesirable ripple effects of their lifestyle changes, i.e., what new habits or ways of living they have adopted in order to mitigate the negative effects and risks associated with these changes.

## REBOUNDS AND RISKS

On the following pages we present a first iteration of cause and effect diagrams (CEDs) that helped visualise rebounds and risks in the workshops. It is important to note that the causes and effects are from the perspectives of individual citizens in the workshops in the five case countries. All causes and all effects are noted for each of the four lifestyle changes, based on notes of motivations, substitutions options, re-spending of income and time and other effects noted by participants. These were not coded as such, but each instance of an effect from the notes was integrated into the CED and traced to the cause noted by the participants. Multiple causes or effects are captured but only distinct effects are included (i.e. an effect is included only once regardless of how many times it is mentioned by participants).

As these results come from the citizens, they are perceptions of their experience. Across the five case countries there were often similar effects experienced, but it is also apparent that citizens have different experiences as well. The same action can have different effects for different people and the same effect can have different implications for different people. This deviates from the causal loop diagrams in literature, where actions have distinct causes (see e.g. Laurenti, 2016b). In reality, from the citizen's perspective, there are often several causes and effects that are interacting and their perspectives incorporate different levels of detail. The individual lifestyle changes were often part of much broader lifestyle changes, which can make it difficult to pinpoint exact causes and effects.

We constructed the CEDs (Figures 4-7) with citizens and asked specifically about key rebound mechanisms (e.g. substitution activities in the same consumption domains, re-spending in other domains and time use). We followed the citizen's narratives documenting causes and effects. Citizens had differing accounts and ability to give specifics about the effect of the action considered on their income or time in terms of more or less, but could give impressions of spending and re-spending more generally. There are thus many different pathways of experiences demonstrated by these CEDs. It is also clear that factors external to the lifestyle change influence the potential rebound effect (e.g. several participants mentioned money saved was only used to meet rising costs of living). The extent of positive or negative effects also depended greatly on the participants' social situations. The CEDs should be viewed as

examples of the complexity and heterogeneity of the experiences of lifestyle changes and some of the possible effects that occur as a result.

The CEDs (Figures 4-7) show the possible rebound effects in relation to greenhouse gas footprints (top part of diagrams). Some re-spending reported by citizens matched other lifestyle changes for further reducing footprints (shown in green) while others demonstrated potential to increase footprints (shown in red). Dotted lines indicate actions for which we have little data as to the impact on footprints or where it is highly dependent on assumptions made (i.e. what kind of charity money is donated to). While how time is used has been demonstrated to affect greenhouse gas emissions, this is often through consumption or spending so we only draw the connection though the income mechanism for these diagrams.

When being asked what rebound effects the participants themselves have noticed from their lifestyle change, a few recurring themes appear in the responses. First of all, several participants have not heard about rebound effects before the workshop, and thus have difficulties or seem uncertain about how to answer the question. Others show an understanding of rebound effects, and as a consequence, seem to be quite aware of how they have spent the surplus money and time resulting from their lifestyle change.

The most common perceived re-spending refers to a general increase in the consumption of consumer goods, such as clothes, outdoors gear, and sports equipment. Furniture (e.g., for saving space), technology and IT gadgets (e.g., for working from home), and other home appliances (e.g., energy efficient equipment) are also mentioned. Furthermore, participants state that they are spending their money on travelling more – either by car (quite often carpooling is brought up, notably among those that have reduced their living space), by plane (notably among those having given up their car), or by public transport. Spending more money on food – e.g., in terms of buying more (expensive) food, more take-away food, and/or visiting restaurants and bars more often – seems to also be common, as well as spending more on experiences and services. In this latter category, prominent themes include e.g., hotel visits, home deliveries, as well as online streaming services and other leisure activities. What is more, some participants claim to have spent more money on electricity, as a consequence of spending more time at home.

The next part of the workshop using the CEDs involved asking participants more broadly about effects beyond substitution actions. It should be noted that the factors mapped in the CEDs are not always consistent, again reflecting differences in the way citizens express and experience effects. The same cause and effect can be experienced as negative by one participant and positive by another. For example, some participants who gave up meat lost weight and whether this was good or bad depended on their weight to begin with. The CEDs also only map all the causes and effects found in the workshops without analysing whether these effects are desirable or undesirable, or tied to specific actions or contexts. In the subsequent section we present the coded analysis from the workshops, which found common themes and indicated the desirability of the different effects noted by participants.

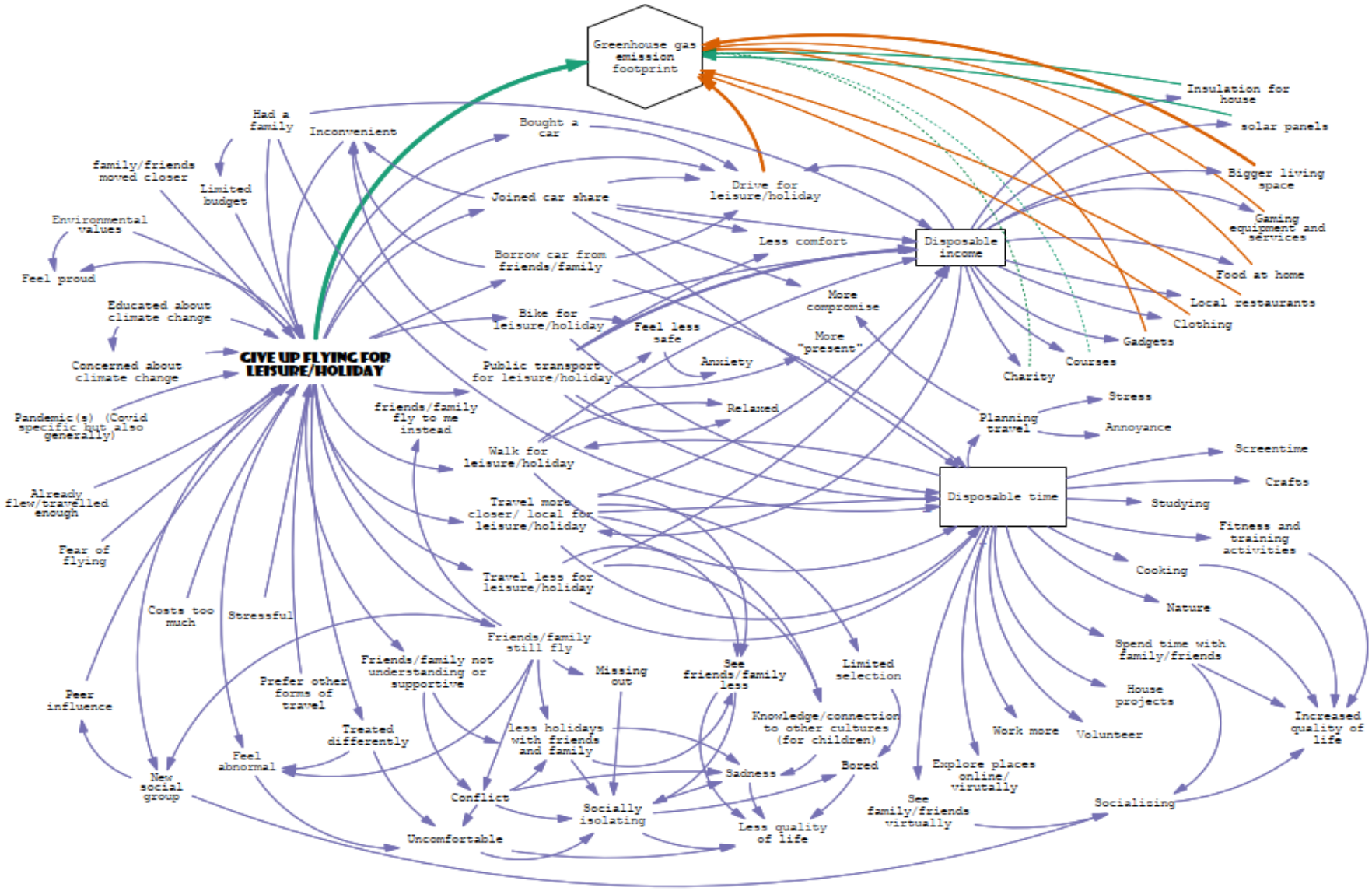


Figure 4. Motivations and effects from giving up flying reported by participants in case countries

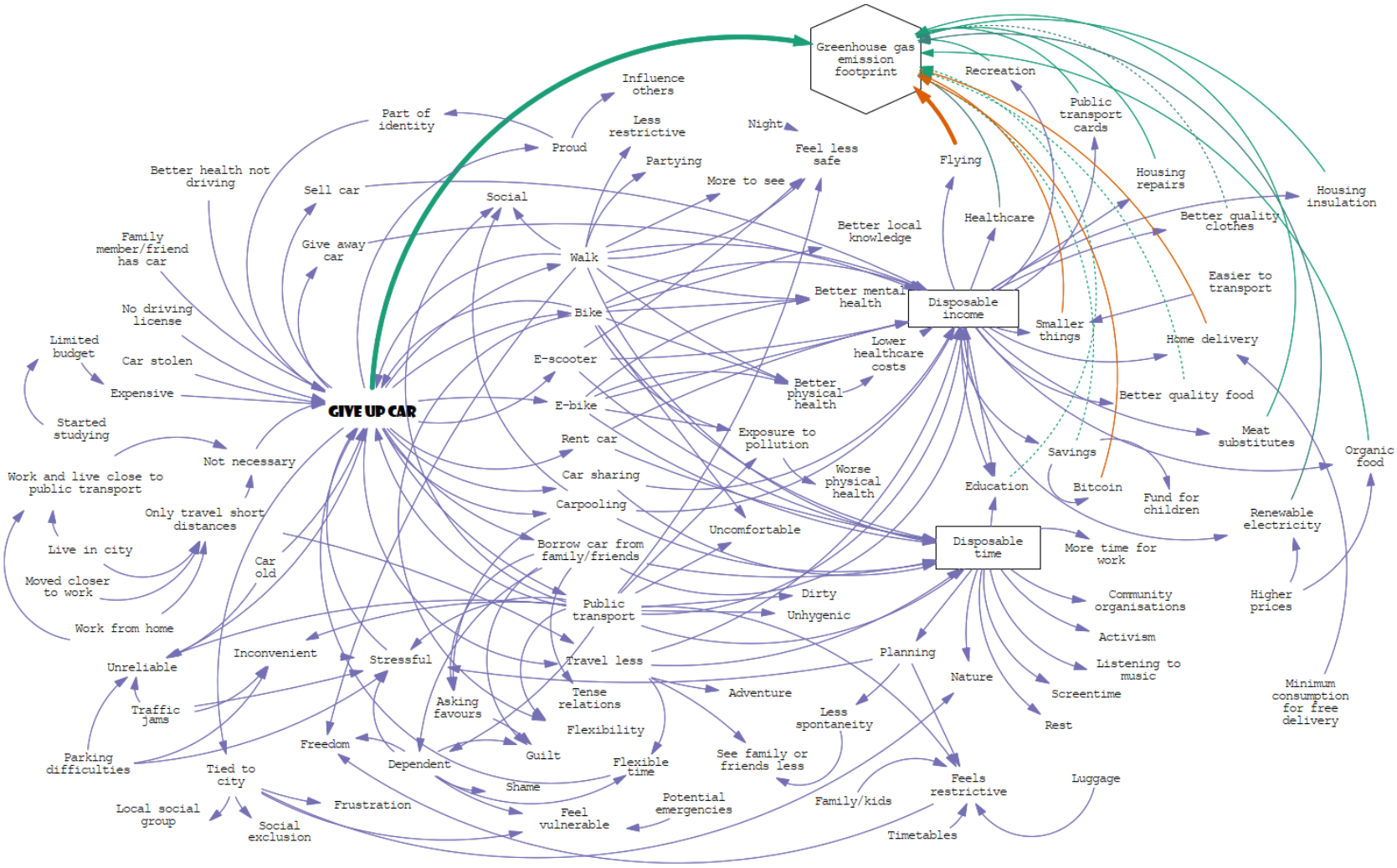


Figure 5. Motivations and effects from giving up car ownership reported by participants in case countries

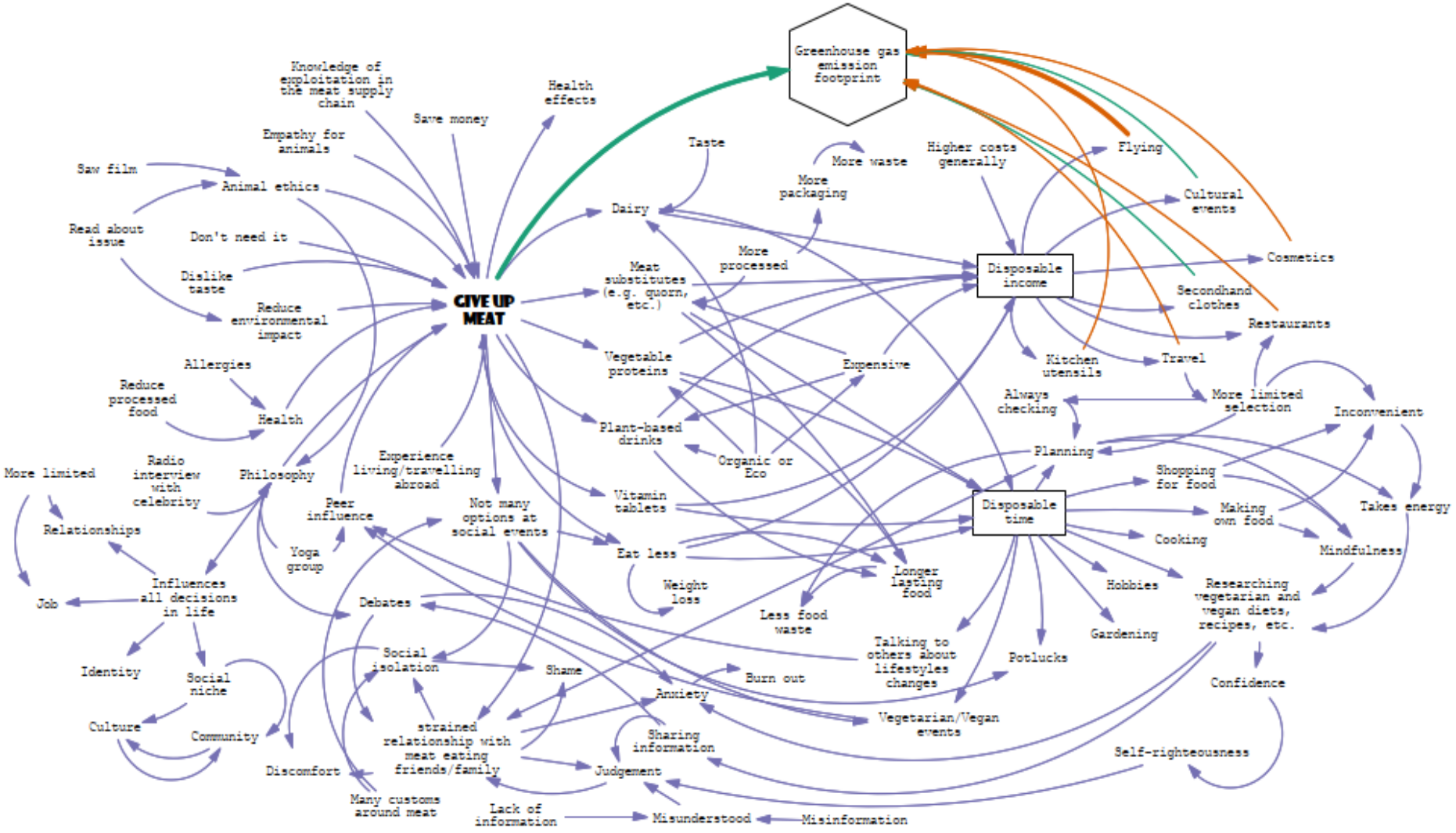


Figure 6. Motivations and effects from giving up meat reported by participants in case countries

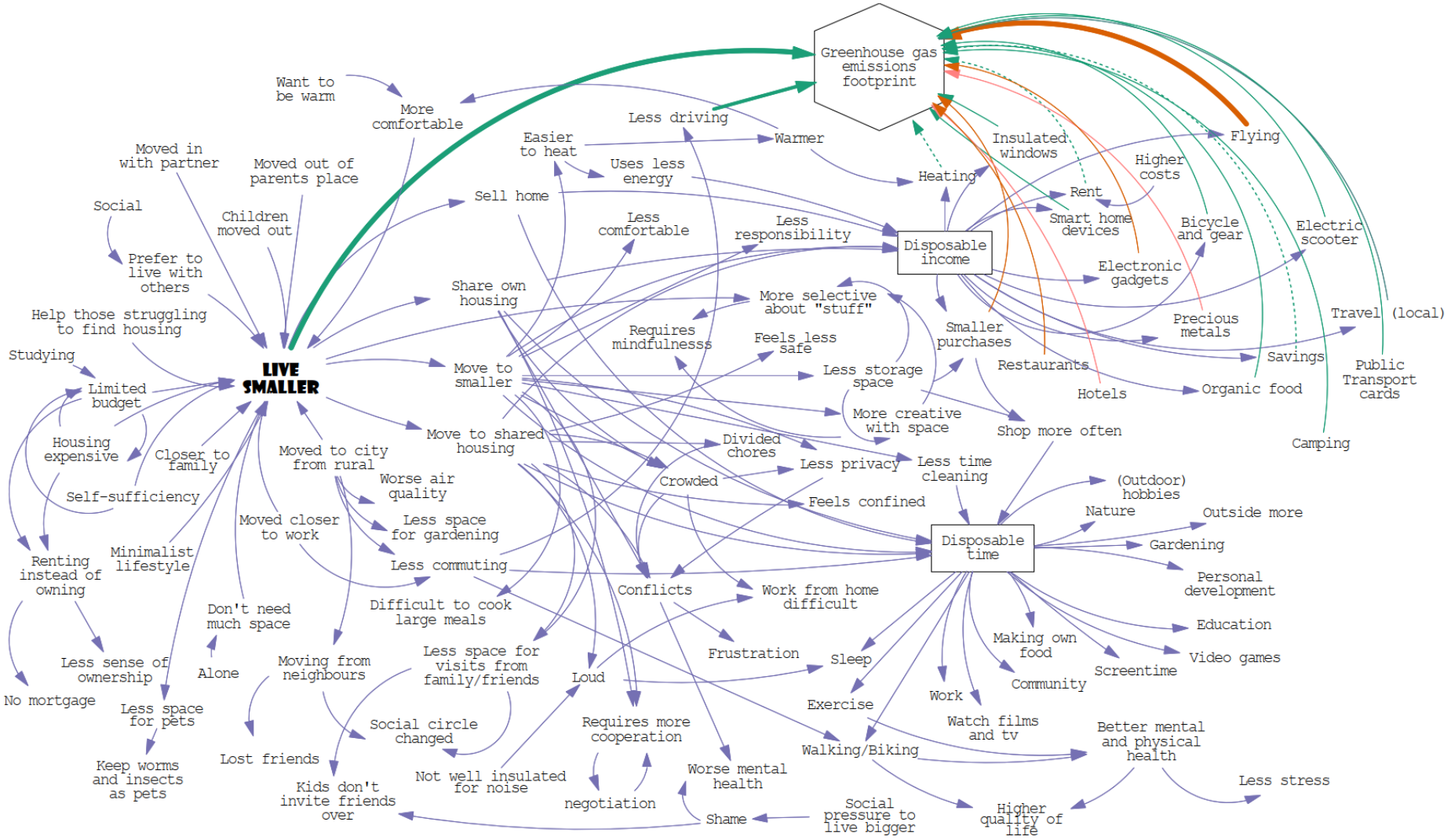


Figure 7. Motivations and effects from living smaller reported by participants in case countries

# REASONS FOR LIFESTYLE CHANGE

In the four chosen high-impact behaviour changes, that is (1) give up flying, (2) give up car ownership, (3) give up meat, and (4) reduce living space to <30m2/person, the underlying reasons were documented based on participants' inputs. The reasons can be divided into the broad, and sometimes overlapping, categories of ***value-based***, ***practical***, ***economic***, ***structural***, ***health-related***, and ***social*** reasons (see Table 3 for key themes and examples). In most cases, participants describe their lifestyle change as based on combinations of these motives.

Table 3. Key themes and examples of reasons for lifestyle change.

| | |
|---|---|
| **Value-based reasons** | - beliefs and values<br>- environmental considerations and/or the climate crisis<br>- empathy and fairness<br>- align with self-image |
| **Practical reasons** | changed personal needs e.g.<br>- family growth<br>- moving in with new partner<br>- moving closer to city |
| **Economic reasons** | E.g. car ownership expensive |
| **Structural reasons** | - well functioning public transport system<br>- limited access to larger accommodation<br>- teleworking |
| **Health reasons** | E.g give up meat to feel healthier or due to allergies or digestive disorders |
| **Social reasons** | - being influenced by friends and other people around |

Most prominent are value-based reasons, i.e., pointing to **beliefs and values**. Across all case countries (especially in cases of giving up flying, car ownership, and meat) the participants attribute their lifestyle change to **environmental considerations and/or the climate crisis**. **Ethics, empathy, and fairness** are also strong recurring themes. For instance, participants that no longer eat meat bring up animal cruelty and animal suffering as reasons for doing so, while participants that have reduced their living space point to fairness issues. Connected to this, several participants talk about their lifestyle changes as a way of **aligning themselves with their self-image**, or who they would like to be.

> *"In the case of the housing change, I was not really looking to live/inhabit a small space, but rather to get to live in a house that would suit my needs and lifestyle. With this I seek to*

> *explain that I do not believe that "more space" is necessary for a better quality of life."* (Participant, Hungary, reduce living space)

> *"I was driven to the decision partly by my self-image as a conscientious person and that I wanted to be credible as a climate activist and environmental scientist..."* (Participant, Sweden, give up flying)

While not mentioned by any of the participants that have given up meat, another prominent theme is practical reasons, i.e., having made the lifestyle change out of **changed personal needs**. This includes, for instance, giving up flying as a consequence of **family growth** since it becomes more complicated to travel with a large family, **moving in with a new partner** and thus ending up having a reduced living space, or selling one's car as a result of **moving closer to the city** and thus finding owning a car redundant. This latter case, which is brought up several times, refers to finding car ownership inconvenient as it is perceived as stressful and time-consuming (considering traffic jams, finding parking, road works, etc).

In addition to being impractical, participants describe owning a car as expensive. Indeed, saving money and other **economic reasons** are commonly brought forward as important motives, notably among the participants that have given up car ownership, stopped flying, or reduced their living space.

Closely connected to practical and economic reasons are structural reasons, i.e., that there are structures in place that facilitate lifestyle changes. Examples include **well-functioning public transport systems** and good train connections, which makes travelling by car or by plane a less convenient option, as well as **limited access to larger accommodation**, which makes living smaller necessary. **Teleworking**, i.e. working from home and/or having more meetings online, is also described as a reason for driving and/or flying less.

> *"Why I gave up my car and started using public transport or cycling is mainly due to where I live in a geographical area where it is easier by bike/bus."* (Participant, Sweden, give up car)

When it comes to **health-related reasons**, these are most notable among the participants who have stopped eating meat. For instance, participants describe giving up meat in order to feel healthier, or due to allergies and digestive disorders. A few participants that gave up flying or car ownership also point to their mental and physical health as reasons for doing so.

Lastly, social reasons – or, **more specifically, being influenced by friends and other people around** – are brought up by participants that have given up meat as well as by those no longer flying. One participant shared during a group session that;

> *"[...] people from the yoga course who practised vegetarianism also strengthened her already present contemplations about whether or not to abandon meat."* (Note-taking, give up meat, Germany)

# UNDESIRABLE RIPPLE EFFECTS

In the following, we outline the undesirable ripple effects, as described by the workshop participants, of giving up flying, giving up car ownership, giving up meat, and reducing living space (see Table 4 for key themes and examples). We demonstrate these results with quotes collected from the individual reflection sheets and the focus group notes.

Table 4. Key themes and examples of undesirable ripple effects.

| Code | (1) Give up flying | (2) Give up car ownership | (3) Give up meat | (4) Reduce living space |
|---|---|---|---|---|
| Less freedom | - missing out on cultural exchanges and knowledge<br>- bound to choose local travel destinations or means of transport | - having to adapt to public transportation and infrastructure and timetables<br>- spontaneous trips to nature more difficult | - limited availability of vegetarian/vegan options | - Less privacy |
| Negative social effects | - having to turn down social events<br>- giving up relationships<br>- conflicts of ethics | - not being able to do favours<br>- feeling like a burden and being dependent on others<br>- impact on social status | - conflicts<br>- refrain from social interactions | - seeing friends and family less often<br>- lacking space for socialising at home |
| Difficult management | - increased travel time | - longer travel time planning and<br>- information gathering regarding timetables, routes and transfers<br>- uncertainty<br>- opportunities for transporting goods and groceries disappear | - additional efforts to sustain meat free diet<br>- spending more time on cooking and meal planning | - lack of living and storing space<br>- additional effort to optimise and plan their home |
| Mental discomfort | - bus, car and cycling feel less safe<br>- sadness and grief<br>- guilt<br>- feel lonely | - feelings of danger and insecurity<br>- feel more exposed | - having to bring your own food<br>- social exclusion<br>- being misunderstood<br>- defend and prove oneself<br>- feelings of not doing enough | - feeling of confinement<br>- worsened mood<br>- conflicts with family members or neighbours |
| Physical discomfort | - public transportation do not match the convenience and comfort of flying | - negative effects of local weather conditions<br>- unhygienic setting | | - less peace and quiet<br>- more noise<br>- negative effects on sleep |
| Worse health | | - more frequent colds<br>- inhaling exhaust fumes | - (initially) negative health effects | - worse air quality |
| Increased expenses/loss of income | | | - meat substitutes more expensive | - unplanned, often more expensive shopping<br>- not being able to shop discounted items in bulk |

## (1) Give up flying

Among the undesirable effects from giving up flying, a sense of feeling limited is prominent. Participants describe how giving up travel destinations means that they are also **missing out on cultural exchanges and knowledge**, resulting in a potential limited worldview. This lack of freedom is often accompanied by **sadness and grief**. Some participants also express feelings of **guilt** when having to fly for work-related matters.

> *"If I do have to fly for work, it makes me feel guilty and bad".* (Participant, Hungary)

The participants comment that they feel like this lifestyle choice has a negative impact on their sense of free choice - characterised by being **bound to choose local travel destinations or means of transport**, not always comparable to flying. These alternative means of transport, such as bus, car and cycling, are also sometimes described as **not as safe as flying**. Using public infrastructure creates feelings of insecurity, due to risks such as getting lost or injured. Travelling by public transport also means **increased travel time,** which some participants state as a negative effect. Furthermore, participants feel less independent when they have to adapt to multiple timetables and transfers, and also express how other means of mobility **do not match the convenience and comfort of flying**.

> *"I lacked the feeling of freedom, I depend on the bus schedule, everything has to follow the schedule, the number of things (bags) I can carry is limited, because I can't carry a lot by myself."* (Participant, Latvia)

By committing to not flying, the participants further respond that this has a negative effect on their social relationships in various ways. The most obvious ones – not being able to visit far away friends and/or join family and friends on trips – make many participants feel lonely as well as guilty for **having to turn down social events**. Some also express unhappiness with having to **give up existing as well as potential relationships with friends abroad**, as virtual solutions cannot always compensate for face-to-face time. Moreover, having to give up or reevaluate relationships is a negative consequence also regarding the local friends. This is due to the fact that the respondents feel that their values and lifestyles no longer match those of their friends, resulting in **conflicts about ethics** and resulting in some participants cutting ties or avoiding the subject of flying altogether with those unable to respect the participant's lifestyle.

> *"I can feel a sadness about not being able to travel freely with my children and "show them the world" the way my parents did".* (Participant, Sweden)

Lastly, the feeling of loneliness and alienation is not only induced by the fact that the participants have to decline social events, but also because many **feel lonely** in their lifestyle choice. They express that the sadness they feel from missing out on experiences and relationships could be relieved if more people in society choose not to fly.

*"It feels hard to shoulder the solution yourself when no one else is doing it."* (Participant, Sweden)

*"Many people in my circle of acquaintances fly and report many experiences. It makes me feel like an outsider."* (Participant, Hungary)

## (2) Give up car ownership

The negative effects from giving up car ownership cause the participants to experience **longer travel time.** Many also express how the **planning and information gathering regarding timetables, routes and transfers**, takes noteworthy time of their hands. Having to trust that the public transportation is on time is an **uncertainty** that the participants are unhappy with, and some report being late to appointments more often. Moreover, as their **opportunities for transporting goods and groceries disappear** along with the cargo space of a private vehicle, many report an increase in frequency of trips for transporting goods.

*"Larger shopping quantities have to be transported back and forth several times (by bike.)"* (Participant, Germany)

Another factor that affects the participants negatively is the reduced freedom and independence. Participants describe how **having to adapt to the public transportation infrastructure and timetables**, sometimes means turning down events, leisure options or job opportunities and makes **spontaneous trips to nature more difficult**. This is also true for the participants' children, who cannot always get to their activities and for this the parents feel guilty. Being dependent on public transport also affects consumption patterns negatively for some.

*"Having to plan around public transport instead of being able to go by car just when you need to, and that stress can also influence my food choices to choose quick and environmentally unfriendly alternatives."* (Participant, Sweden)

One of the most common negative effects in regard to the participants' social life is **feeling like a burden and being dependent on others.** Having to ask others to drive them or transport goods, makes the participants feel selfish and vulnerable. Some also express how not having a private car **impacts their social status**, and that they worry that people will think they are poor. The participants' social life is also negatively impacted by the fact that they cannot visit far away friends and family as often. Having a car meant that they could offer a ride to friends and family in the past, and **not being able to do favours** for others in this way is affecting their social life and identity negatively.

*"My teenage daughter had to cancel certain parties because we couldn't drive her home at night."* (Participant, Hungary)

> *"Negative social role as a free rider ("Trittbrettfahrer") who relies on someone else to provide and drive a car during group activities. The latter is particularly relevant in the context of driving to parties, as the driver cannot drink then."* (Participant, Germany)

This lifestyle change increases many participants' **feelings of danger and insecurity**, and being a pedestrian or biker makes the participants **feel more exposed**, notably at night. Related to this is the negative effect of not being able to trust that they or loved ones can get to a hospital in time in case of an emergency, which also make many participants feel like they are taking a risk by giving up car ownership.

> *"As a cyclist and pedestrian, you are less protected and it is difficult to know whether the car will stop or not, you get scared."* (Participant, Sweden)

The **negative impact of local weather conditions** is also a notable negative consequence. Comments about physical discomfort such as freezing while biking or waiting for a delayed bus, or getting too hot as a result from not having a private car with air conditioning, is typical. Regarding public transport, some participants describe an uncomfortable feeling about the **unhygienic setting** relative to a private vehicle, and others who now bike more experience more **frequent colds** and **inhaling exhaust fumes** from traffic.

## (3) Give up meat

A recurring undesirable effect reported among the participants who no longer eat meat is the **additional efforts** that are needed to sustain a meat-free diet. Some participants describe having to visit various different supermarkets, due to a **limited availability of vegetarian or vegan options**. Connected to this, many participants describe such options (in particular meat substitutes) as **more expensive**, as well as generally generating more (plastic) packaging waste than other diets. Other examples of additional efforts include **spending more time on cooking and meal-planning** – notably if not everyone in the household follows the same diet – and having to prepare vegetarian or vegan meals at home, given a lack of such options in e.g. school canteens, when travelling (to new places), or when visiting friends.

> *"It is also difficult to prepare food for travel/trips, unless you are travelling to vegan friends or to a more enlightened venue/event where vegan food is available (but this is rare)."* (Participant, Hungary)

Connected to these additional efforts – summarised by one of the participants as 'creating a fuss about the food' – are feelings of stress and shame. Participants describe how **having to bring your own food**, or creating inconveniences in other similar ways, puts a strain on their social life. Feelings of **social exclusion**, **being misunderstood**, or having to **defend and prove oneself**, are prominent themes. Many participants point to a lack of understanding or acceptance from family and friends, sometimes resulting in **conflicts** or deciding to **refrain from certain social interactions**. Some participants describe feeling frustrated, hopeless or sad by seeing that so few people are changing their lifestyle, or – connected to the **feeling of 'not doing enough'** – by looking back at their own life before giving up meat. For example, the

Swedish focus group noted that:

> *"[it] can be stressful that you have to know so much about health and diet to defend and prove that you get enough as a vegan - can also be stressful mentally to defend your own diet - and stressful to come as a guest with special requirements, where you may have had to bring your own food - which is a bit of an omission, almost embarrassing."* (Note-taking, Sweden)

What is more, some participants describe **negative health effects** from giving up meat – especially initially, before getting more used to the new lifestyle – stemming from insufficient knowledge of what to eat in order to sustain a healthy meat-free diet.

## (4) Reduce living space

For many of the participants, the biggest problem of living smaller is a **lack of living and storing space**, leading to e.g., difficulties to store furniture, clothes and food, and to accommodate overnight guests. The lack of storage space is described to result in **additional efforts to optimise and plan their home**, resulting in e.g. having to dispose of (unnecessary) items as well as in refraining from buying new things.

> *"If I lived in a bigger apartment I would have kept more stuff. So it wasn't even an option to keep many things, so I had to pick 1 out of 10 things, the rest we took to charity shops. It was not necessarily out of free will, but out of necessity."* (Participant, Hungary)

However, some of the participants also bring up examples of increased levels of consumption as a result of a reduced living space. For instance, **not being able to shop discounted items in bulk**, or to cook larger amounts of food at home, is associated with more **unplanned, often more expensive shopping**.

> *"The main negative effect I noticed when moving to a smaller house is obvious: A lack of space. This in turn brings with it a number of consequences: It is not the ideal place to invite friends or family for meetings at home, which means that these meetings always have to be held in catering establishments (more consumption) or in other people's homes. It does not facilitate shopping for large food purchases (which would save money) due to lack of storage space."* (Participant, Spain)

The lack of space for inviting people over for dinner or for staying the night is described as resulting in **seeing friends and family less often**, or having to rely on meeting elsewhere, which may entail undesired, additional costs. Furthermore, several participants comment that **lacking space for socialising at home** – along with living smaller in general, especially if sharing the space with others – means **less privacy, peace and quiet**. Some participants describe that the space constraints limit the possibilities for indoor and outdoor hobbies, such as playing an instrument, or gardening at home. The lack of personal space is leading to different facets of mental discomfort – such as a **feeling of confinement**, **a worsened mood,** and **conflicts with family members or neighbours** – as well as physical discomfort. Many participants describe that living more densely means **more noise**, which **negatively affects**

**their sleep**, and in some cases **worse air quality**.

> *"With shared accommodation, I also feel that I have less privacy and time for myself. Sometimes I can feel irritated and disturbed by the constant noise from others, which can affect my mood. This also affects my sleep. There is more noise around which means that the number of hours of sleep can be reduced."*(Participant, Sweden)

### Country-specific findings of undesirable ripple effects

While similar effects are experienced across the five case countries, some findings are specific to only one or a few of the countries. With regards to the undesirable ripple effects described above, it should be noted that **Sweden** is the only case-country in which participants report feeling a sense of hopelessness as a consequence from the lifestyle change, and **Hungary** is the only case-country in which participants report experiences of unclean public transport as an undesirable effect from not having a car. Furthermore, **Latvia** is the only case-country in which no participants report spending less time with family and friends as a consequence of the lifestyle changes, and **Spain** is the only case-country in which no participants report feeling less security and more fear as a consequence from the lifestyle change. Only participants in **Hungary**, **Latvia** and **Sweden** report being late more often as an effect from the lifestyle change. Connected to this, only participants in **Hungary** and **Sweden** report experiencing less certainty in daily life generally. Lastly, **Hungary**, **Spain** and **Sweden** are the only case countries in which participants report feelings of frustration as an effect from the lifestyle change.

## DESIRABLE RIPPLE EFFECTS

In this section, we describe the desirable ripple effects of giving up flying, giving up car ownership, giving up meat, and reducing living space, experienced by the workshop participants (see Table 5 for key themes and examples). We demonstrate these results with quotes collected from the individual reflection sheets and the focus group notes.

Table 5. Key themes and examples of desirable ripple effects.

| Code | (1) Give up flying | (2) Give up car ownership | (3) Give up meat | (4) Reduce living space |
|---|---|---|---|---|
| Positive spillover | - hiking and biking more<br>- experience local nature<br>- energy efficient renovations<br>- supporting the local community and economy | - relocate to areas with access to low-carbon mobility infrastructure | - increased knowledge of meat free diets<br>- increased awareness of climate intense behaviours<br>- new food related consumption patterns<br>- generally less consumption | - consuming less and decluttering<br>- donating still usable items<br>- sharing appliances<br>- using less cleaning and maintenance products<br>- less waste<br>- better access to low-carbon mobility infrastructure<br>- promoting community |

| | | | | |
|---|---|---|---|---|
| | | | | and neighbourhood life<br>- energy efficiency renovations<br>-organic and healthy food |
| Mental comfort | - strong sense of pride and role model<br>- quality of journey changed for the better<br>- feel more relaxed and present when travelling | - decreased level of stress<br>- more satisfied with life and values<br>- liberating feeling | - increased self-confidence | - more free time<br>- more time available for leisure and hobbies<br>- increased quality of life |
| Positive social effects | - stronger relationship with family and others in local area | - able to interact with new people | - influencing family and friends | - quality time with friends and family |
| Better health | - increased mental and physical well being<br>- invest in a healthier lifestyle | - more active lifestyle<br>- spending savings on exercises and healthier food | - feeling healthier | - positive health effects |
| Cost savings | | - not spending money on car maintenance and fuel | | - lower expenses for e.g energy and rent |

## (1) Give up flying

Several of the participants that used to fly but have stopped flying, express **a strong sense of pride** about their decisions. Some participants express how being a **role model** and an ambassador of change for their children, or a *"part of the solution rather than the problem"* as stated by one participant, means a lot for their self-image.

> *"I try to stand tall and proud of my decision and focus on the fact that the change in behaviour relieves my climate conscience."* (Participant, Sweden)

Other desirable effects that the participants experience is a higher level of satisfaction in their life, which in turn is due to many different factors. Some state that as they started travelling with slower means of transport, such as train or biking, they felt that the **quality of the journey changed for the better**. Also, the fact that the time spent on transporting oneself becomes a part of the vacation itself, has shifted their perspectives on time and makes them **feel more relaxed and present.** Being able to effortlessly experience the environment shifting around oneself while travelling, is another example of this desirable effect.

> *"The first effect I noticed was the improvement in the quality of the journey. Less stress, less waiting hours and less physical and mental energy spent [...]. I can enjoy travelling in a healthier and more coherent way with my philosophy."* (Participant, Spain)

Additionally, those that respond that they are doing more **hiking and biking** now than when they used to fly, feel both that being in nature and getting to **experience their local nature** more, **increase their mental and physical well-being**. Some report that their lifestyle change increases their disposable income which they can invest in **energy efficient renovations** and house improvements, such as installing solar panels. Others **invest in a healthier lifestyle,** which includes both mental and physical health as described by Spanish participants in a focus group session;

> *"[...] alternative behaviours, such as hiking, increase their quality of life. In addition, it is a physical activity that has a benefit for their health, which they directly relate to benefits in their mental health."* (Note-taking, Spain)

Moreover, a recurring positive effect from rejecting far away destinations, is the opportunity to support the local community and economy to a larger extent. Many express that travelling closer to home increases their appreciation of their local nature and tourism, and that they also feel they have more time to explore these areas more in depth. Others mention developing **stronger relationships to family and others in the local area**.

## (2) Give up car ownership

By not having a private car, the participants say that their **level of stress has decreased** (e.g. no concern for parking spots, traffic, car insurance and repairs). Some participants mention the desirability of not being restricted anymore also regarding the fact that they can consume alcohol more spontaneously. **Not spending money on car maintenance and fuel**, also has a significant positive impact on the participants' cost savings. Almost all participants comment that their overall health has improved since giving up the car, and some also point out that they save money on healthcare costs, due to a **more active lifestyle** and **spending savings on exercises and healthier food**. As the participants' life quality increases, they report being overall **more satisfied with their life and values**. Many also express a **liberating feeling** of being car-free.

> *"Not having to deal with possible unexpected expenses that can occur with the vehicle, such as taxes, ITV (vehicle inspection), and repairs, provides a sense of tranquillity, knowing that you won't have that possibility of an unforeseen expense that could disrupt your finances".* (Participant, Spain)

> *"Enjoyment and peace of mind as you don't have to focus on the traffic."* (Participant, Sweden)

Beneficial impacts on the participants' social lives are also an important aspect of living car

free. Many report **being able to communicate and interact more with new people** more often as they spend more time in the public space and on public transport, which strengthen their social skills and their social identity. Those using carpooling and car sharing schemes also report that it is a good way to meet new people.

> *"I walk and use public transport. It takes a lot of time, so I try to benefit from it - I listen to records in transport, I use the time to think. While walking, I call my friends or talk on the phone."* (Participant, Latvia)

Giving up car ownership has also impacted the participants' living situations. Some state that it led them to **relocate to areas with access to low-carbon mobility infrastructure,** such as better public transport, or where their daily activities are by walking or biking distance. This meant that their overall travel distances decreased, and accessibility to leisure and work increased.

## (3) Give up meat

One of the main desirable effects from giving up meat reported by the participants is an **increased knowledge** of related topics, such as meat production and consumption, cooking, and what constitutes a healthy, meat-free diet. This learning process is in some cases leading to a sense of **increased self-confidence**.

> *"I have accumulated a lot of nutritional/health knowledge - I pay more attention to monitoring my/our health."* (Participant, Hungary)

> *"Lots of self-development, learning, research, to gain confident knowledge."* (Participant, Hungary)

Furthermore, many participants describe positive spillover effects resulting from the decision of stopping to eat meat. These can be summarised as an **increased awareness of climate-intense behaviours** in general translating into **new food-related consumption patterns**. Reported behavioural changes include starting to buy more organic food and local produce, growing and producing their own food (e.g., gardening, picking wild plants), and switching to a fully plant-based lifestyle. Others mention cutting down on plastics and dairy products, measures to create less (food) waste, setting up a compost at home, and **generally consuming less**, for instance by buying less clothes or starting to dumpster-dive.

> *"By ditching meat, I started changing my consumption behaviour in other areas as well, step by step, including reduction of used plastics and dairy products."* (Participant, Germany)

> *"I changed my view of myself when I became vegan which led to positive side effects where I also thought about waste sorting, reduced consumption, etc. I set a picture of my identity where I wanted to have as little impact on the climate as possible and a greater openness to new lessons about individual changes."* (Participant, Sweden)

Some participants describe spillover effects on the social level. Sometimes, giving up meat

has **influenced family members and friends** to stop eating meat as well, or decrease their levels of meat consumption and/or to gain a more positive attitude towards vegetarian and vegan food. Entering discussions about climate change with people around is also brought up. Other positive effects mentioned by the participants include **feeling healthier.**

## (4) Reduce living space

The most prominent positive effect of living smaller seems to be related to having less space to maintain, furnish and keep clean, as well as less space to store unnecessary items. As a result, participants free up space by **consuming less and decluttering** – resulting in, to quote one of the participants in Latvia *"conscious minimalism on a daily basis"*. Others engage in sharing or circular activities, such as **donating still usable items** or (in cases of shared housing) **sharing certain appliances**, such as kitchen equipment and cleaning supplies with roommates. Furthermore, having to more carefully plan one's purchases of food and other goods (due to space constraints), as well as **not having to use as much cleaning and maintenance products**, is reported to result in **less waste**.

> *"Due to the smaller space, we gave away a lot of still usable items (books, clothes, dishes, furniture), so they became reused items."* (Participant, Hungary)

> *"We also encourage reducing material consumption, since we do not have enough room for storage, and we have to be more proactive in this area."* (Participant, Spain)

Additionally, for many of the participants, moving to a smaller home resulted in living more centrally with **better access to low-carbon mobility infrastructure.** Connected to this, some also reported perceived **positive health effects** and local engagement and consumption, thus **promoting community and neighbourhood life**.

According to close to all participants, living in a smaller, more space-efficient (and often more central) home has resulted in having **more free time.** As a result, participants describe positive effects on their mental health as well as their social life, stemming from having more time available for **leisure and personal hobbies** – specifically, relaxing, outdoor activities, gardening, and learning new things, are mentioned – as well as for spending **quality time with friends and family**. Some participants state that they experience an **increased quality of life,** due to the simplicity of living smaller (e.g., due to having relatively small financial flows, no big mortgages), leading to less stress.

> *"I shifted activities to outside [...]: time for myself, friends, family, time for reading..."* (Participant, Germany)

Lastly, some participants bring up that they have used the cost savings from living smaller – resulting from **lower expenses for e.g. energy and rent** – to **invest in energy efficiency renovations** of the home as well as to buy more **organic and healthy food**.

**Country-specific findings of desirable ripple effects**

A few of the experienced desirable ripple effects are case-country specific. **Hungary** is the only case-country in which no participants say they have more quality alone time since the lifestyle changes, and **Sweden** is the only case-country in which no participants report doing more gardening as a positive ripple effect from the lifestyle change. Moreover, **Sweden** and **Spain** are the only case-countries in which no participants say they are able to drink alcohol more frequently as a positive ripple effect from not having a car.

## MANAGING REBOUNDS AND RISKS

When it comes to how the participants were able to avoid rebounding from their lifestyle change, as well as to how they managed the undesirable ripple effects (i.e. the social risks) stemming from the lifestyle change, the participants described a variety of individual strategies. The participants also shared many suggestions for how policies and structural changes could aid and prevent re-spending their time and money on carbon-intense activities, as well as ideas for how positive spillover could be enhanced (see Table 6).

Table 6. Policy suggestions by participants to mitigate rebounding and enhance positive spillover

| | |
|---|---|
| **Accessible and affordable alternatives** | e.g through advertising, subsidising, tax incentives, making more areas car-free, abolish subsidies on flights and meat products, bonus-systems |
| **Change social norms** | e.g spread narratives about positive benefits, normalise and destigmatize living low-carbon, remove status around excessive consumption, be more open and compassionate towards each other, social media/influencers to show success stories of sustainable lifestyles |
| **Support sharing economies** | e.g legal frameworks for car sharing, create more community gardens and shared spaces, platforms for sharing items, ideas and skills about sustainable lifestyles |
| **Education and information** | e.g. raise public awareness about rebounds, apps showing costs of different things to monitor spendings, information about product origin and manufacturing process, adapt school curricula to sustainable lifestyles, more information about vegetarian/vegan lifestyles |
| **Collaborations** | e.g cross-transport mode platforms for easier trips, more citizen thinking labs together with decision makers, manufacturers made responsible for fair production and repair through EU legislation |
| **Support sustainable lifestyles** | e.g increase self-sufficient, more car-free areas, accessible recycling, limit work-trips, develop biking infrastructure, social benefit-based pension system (that won't punish reduced working hours), income cap (to prevent unnecessary consumption as a result from unnecessary wealth), implement personal carbon budgets so people can't rebound |
| **Infrastructure** | e.g make streets safer for pedestrians and women, improve urban/rural connections, provide housing for large employers, prioritise housing renovations to new constructions, make rural setting more attractive for local tourism, means-test car ownership |
| **Investments** | e.g in energy efficiency, IT solutions, green companies that provide low-carbon alternatives for tech, services and products |

## Mitigating rebound effects

This section outlines the most common themes brought up by the participants – across the four lifestyle changes – with regards to how they have avoided rebound effects, along with quotes collected from the individual reflection sheets (see Table 7 for key themes and examples).

Table 7. Key themes and examples of strategies for mitigating rebound effects.

| | |
|---|---|
| **Conscious consumption** | - general mind-set of "climate awareness"<br><br>actively restrict what they believe to be carbon-intense activities, e.g.<br>- travel less (far)<br>- avoid resource-intense food<br>- avoid certain transportation modes (e.g., flying)<br>- not make any spontaneous purchases<br><br>actively increase what they believe to be low-carbon activities, e.g.<br>- buying more healthier and/or organic food<br>- making energy efficiency renovations at home<br>- travelling by train, bus or bike<br>- donating, saving or investing surplus money |
| **Conscious spending of time** | - being more outdoors<br>- gardening<br>- growing food<br>- going on walks and bike-trips<br>- working less<br>- working more from home<br>- online meetings<br>- information/education |
| **Structural and physical enablers** | E.g. no room or need for having a car |
| **No net cost or time savings** | - travelling by public transport takes more time<br>- expensive vegetarian diet<br>- increased electricity prices<br>- high inflation rate |

In order to mitigate rebound effects, what appears to be the most common strategy among the participants is to **engage in conscious consumption**. Across the five case countries, and across the four case lifestyle changes, participants describe how they actively think about and make deliberate decisions regarding how to use the savings resulting from the lifestyle change in order to avoid rebounding. Often, this dedication is sprung from a strong awareness of the environmental impacts of consumption and/or the underlying mechanisms of rebound effects. While some participants mention specific consumption decisions (e.g., consciously avoiding flying), others rather describe a more **general mind-set of "climate awareness"** in their day-to-day life.

> *"The reason for changing my behaviour was a concern about the environmental consequences of my behaviour, so I avoided the rebound effect by becoming more aware of those behaviours that could jeopardise my goal. If I stop using a car but take a plane more*

> *often, we won't achieve anything, so I try to compensate for this."* (Participant, Spain, give up car ownership)

> *"I'm quite aware of the climate impact of my consumption and try to avoid rebound effects."* (Participant, Sweden, give up flying)

Overall, the participants' conscious consumption decisions can be divided in two broad categories: they **actively restrict what they believe to be carbon-intense activities**, and/or **actively increase what they believe to be low-carbon activities**. Within these two categories, the participants' choices may relate to the same consumption domain as their lifestyle change, thus avoiding direct rebound effects – e.g. *"I avoid this type of transport, without using other alternatives that could increase the ecological footprint."* (Participant, Spain, giving up flying) – or to other consumption domains, thus avoiding indirect rebound effects – e.g., *"Money could be* used *for flying, but deliberately will NOT."* (Participant, Germany, giving up car). With regards to actively restricting certain activities, examples include deliberately deciding to **travel less (far)**, **avoid resource-intense food** and **certain transportation modes (e.g., flying)**, and **not make any spontaneous purchases**. Examples of actively increasing certain activities, on the other hand, include **buying more healthier and/or organic food**, making **energy efficiency renovations** at home, travelling by **train, bus or bike** instead of by car, and **donating, saving or investing** the surplus money.

> *"As expenses for housing utility payments decreased - we invest those funds in the education of children's interests (sports, music) so that there is no desire to buy extra things that are not really necessary. These activities are as close as possible, so that it is possible to go on foot or by bicycle."* (Participant, Latvia, reduce living space)

> *"[I] donate savings to nonprofit organisations, especially for animal protection"* (Participant, Germany, give up flying)

Another recurring theme and somewhat overlapping with the strategy of actively restricting/increasing consumption, is making **deliberate choices regarding how to spend time**. Several participants describe how they have picked up new hobbies, often involving **being more outdoors**, such as **gardening**, **growing food**, and going on **walks and bike-trips** in their local area. Some participants – notably among those that have given up their car or reduced their living space – bring up new ways of spending time in relation to their working life as well, such as **working less**, **working more from home**, or holding more **online meetings**.

> *"I fill my time with civic activism in the field of urban environment. Accordingly, even if I spend less time not being in a traffic jam, the remaining time is spent convincing and sometimes forcing others to choose a means of transport with lower emissions. The money I don't spend on fuel and emission taxes, I basically invest in my hobby - board games. I'm not sure if it helps to avoid the rebound effect."* (Participant, Latvia, give up car ownership)

Connected to the strategy of making deliberate choices regarding how to spend surplus money and time is to learn about behaviours with high climate impact. Several participants describe how they try to **stay informed and educate themselves**, for instance, by online research, or by

monitoring their behaviour using smart thermostats or apps.

> *"I believe that measures (both private and institutional) of information on the cost or production footprint of products have helped me a lot in this (thinking more carefully)."* (Participant, Spain, give up meat)

> *"I try to make myself aware of the consequences of anti-climatic behaviour."* (Participant, Germany, give up flying)

In addition to making active choices, participants in all groups except the give up flying group point to **structural or physical factors** as reasons for why they have been able to avoid rebounding. Notably, participants mention that by living centrally (which is the case for many of those having reduced their living space), there is neither room nor a need for having a car. Among those participants not living in the city, some have chosen to move close to a train station, in order to avoid increased car reliance.

> *"The new smaller home is also more central than the previous one, which has meant that I can cycle or walk to where I need to go. Instead of travelling by car or bus."* (Participant, Sweden, reduce living space)

Lastly, across the case countries, there are a few participants who bring up that in their experience, there have been **no net money or time savings** as a result of their lifestyle change, and thus, they have avoided potential rebound effects. The most recurring examples refer to **travelling with public transport which is considered to take more time** compared to flying or going by car. No perceived cost savings, on the other hand, are most often brought up by participants who have stopped eating meat or have reduced their living space, and to some extent also by those that have stopped flying. The reasons for not having experienced any increase in disposable income vary among the participants, but many refer to **expensive vegetarian diets**, the recent general **increase in electricity prices** and – in some of the cases, dependent on country and product – **high inflation rates**.

> *"Have used public transport instead of long journeys, these have not saved money or time. So automatically, there have been no rebound effects."* (Participant, Sweden, give up flying)

### Country-specific findings regarding mitigating rebound effects

With regards to case county-specific mitigating strategies, a few things can be noted. **Hungary** and **Spain** are the only case-countries in which participants report having practised low carbon employment (teleworking etc) as a way to avoid rebounding. Furthermore, only participants in **Germany**, **Hungary** and **Spain** report that they try to educate themselves or gather more information as a way to avoid rebound effects.

## Managing social risks

In this section, we outline the ways in which the workshop participants – across the four lifestyle change groups – report having managed the undesirable ripple effects (i.e. the social risks) from their lifestyle change, along with quotes collected from the individual reflection sheets (see Table 8 for key themes and examples).

Table 8. Key themes and examples of strategies for managing social risks.

| | |
|---|---|
| **Accept** | - accept challenges<br>- tolerance and patience increase<br>- learning to live with changes<br>- focus on positive |
| **Plan and reorganise time** | - changing the way grocery shopping is planned<br>- eating before going to events<br>- bring own food<br>- change the timing of certain activities at home<br>- change where time is spent |
| **Reorganise and reduce personal belongings** | - reevaluating items<br>- increasing utility of items |
| **Change others** | - activism<br>- discussions<br>- citizen participation |
| **Challenge norms** | - challenging cultural norms<br>- challenging mobility norms |
| **Avoid** | - conversation topics, situations, and/or people |
| **Medical or professional help** | - consult with dietitian<br>- consult with therapist<br>- medical checkups |
| **Social networking** | - engage in car-sharing communities<br>- rely on other for driving them or their goods<br>- new communities<br>- help from family and friends |
| **Virtual and IT solutions** | - attend work meeting and other events online<br>- using phone and video communication platforms<br>- videos, taking online courses and/or reading |

As the participants express how the lifestyle changes initially came with some uncomfortable adjustments, such as limiting travel destinations or giving up relationships, one of the most common ways to handle these losses was to just **accept these challenges** and the situation for what it was. Similarly, many express how their **tolerance and patience has increased**, both for others and for themselves in terms of **learning to live with these changes**. Others mention that this strategy needs time and dedication.

> *"I have to accept that I don't have the right to go everywhere".* (Participant, Hungary, give up flying)

> *"Accepting that you have to take on certain challenges/difficulties for a better goal/quality of life = there is no easy way, we humans struggle with problems precisely because everyone wants to take the easy way."* (Participant, Hungary, give up meat)

A mindset that is mentioned across all lifestyle changes, is to try to **focus on the positive.** This strategy is closely tied to keeping in mind the shared external values and positive effects from the lifestyle change rather than the negative personal effects, even if personal benefits such as economic savings and improved health are acknowledged.

> *"It is difficult at first to give up the comfort of using a private vehicle, however, it is necessary to think about the positive aspects of giving up - reduction of carbon emissions, economic effects, etc."* (Participant, Latvia, give up car ownership)

One of the more popular new habits across all of the lifestyle changes, is planning and organising time differently. For example, participants mention new shopping behaviours, such as **changing the way grocery shopping is planned** according to accessible vegetarian options, prices, and transport. Many in the group who have stopped eating meat also state how they often adopted new eating patterns, such as **eating before going to events** and often **bringing their own food** to work or events. Through planning, many have learned to live like this, and some also suggest a better sense of time-management overall.

> *"By planning more, experience is gained and as a result less time is spent on planning than before."* (Participant, Latvia, give up car ownership)

> *"I started meal prep, so if I make soup or salad, I have enough for several meals or even days."* (Participant, Latvia, give up meat)

Other ways of reorganising time is to **change the timing of certain activities at home**, such as studying, cleaning or hobbies, to minimise the risk of disturbance and to get the most out of the activity despite the additional efforts initially required. This is also true for leisure activities outside of the home, and many participants mention that even if adapting to the lifestyle change initially was time consuming, the quality of each activity increased.

> *"I have also attempted to make the most of the free time devoted to leisure and culture by concentrating it on specific days of the week, in an attempt to minimise the expenditure of transport or time. In this sense, I have also maintained a more casual leisure life, something that I can enjoy in my environment."* (Participant, Spain, reduce living space)

Across the lifestyle changes, the participants have also **changed where they spend their time**. Notably, those who reduced their living space now spend more time outside, both in order to socialise, practise new hobbies, and to get privacy. At the same time, spending more time indoors is also a common new habit, and especially true for those that report cooking more at home since giving up meat. Across all lifestyle changes – except the give up car ownership group – participants mention spending more time at home, both for hobbies, leisure and work.

> *"Doing many things more outdoors now because of smaller living space; watching less TV because of less space for a big TV, but feel more motivated to go into the garden or going out jogging."* (Participant, Germany, reduce living space)

Inevitably, reducing one's living space or transportation alternatives, also meant that the participants learned how to **reorganise and/or reduce the number of personal belongings**. This new habit affects the participants' consumption patterns by *"thinking twice before buying a new item*" as mentioned by a Hungarian participant, or **reevaluating or increasing their existing items' utility** to be multifunctional.

> *"In the family, we agree on who uses public transport and who rides a scooter or bicycle."* (Participant, Latvia, give up car ownership)

> *"The most important change I have made to facilitate this is learning to live in a more space-efficient way, with less material things and spending more time outside."* (Participant, Spain, reduce living space)

Another popular strategy among the participants is to try to **change or influence others and society;** either to make others adapt to the participants' new lifestyle, or to change others' way of living. This is done in many different ways, such as **activism** and **discussions**, as well as more formal communication formats such as **citizen participation**:

> *"With regard to the dependence on timetables and availability of transport, on several occasions I communicated the problems of accessibility and timetables to the relevant City Council and proposed improvements; sometimes with positive results, sometimes not, but always with the positive side of getting more involved in local politics."* (Participant, Spain, give up car ownership)

> *"I tried to convince friends and acquaintances to make the same lifestyle change."* (Participant, Sweden, reduce living space)

In all groups except the give up flying group, there are participants who bring up that their lifestyle change has brought them to intentionally challenge norms and risks – a strategy closely related to both accepting the lifestyle change and feeling the need to change others. For example, some participants who have given up meat express a motivation to **challenge existing cultural norms** around the importance of eating together, in order not to feel awkward about eating before events. Others mention organising potlucks or challenging the norms in the way they organise social events:

> *"We cook smaller portions of several things, so everyone eats more slowly and that, plus the variety, fills them up, plus I've added other activities to family lunches, e.g. after lunch we walk through the park to the café so they can have coffee there to top off lunch (and it turns out they're not hungry)."* (Participant, Hungary, give up meat)

Similarly, participants who now rely on biking or public transport to get around, respond that they take the risk of bike theft or even having to change jobs, in order to stick to their cause

and thereby **challenge mobility norms**.

> *"In some cases, in relation to work, I was able to negotiate timetables with the company to accommodate public transport. In other cases, I simply quit those jobs."* (Participant, Spain, give up car ownership)

Opposite to the motivation of challenging norms and changing others to adapt to this new way of life, some participants also say that they have resorted to **avoiding certain conversation topics, situations, or people.** This behavioural strategy is popular among the participants who experience strain on social life and feeling alienated; by avoiding the situations that makes them feel bad, they claim this effect is managed better. Those participants that feel unsafe and exposed outside after giving up their car, also report avoiding certain areas or going out at night.

> *"Sometimes, having a special diet, I stopped going to places, celebrations, and meals such as "barbecuing", which are very typical in my circle of friends."* (participant, Spain, give up meat),'

> *"Avoiding the conversation that the reason for not flying is because of the climate with family and friends."* (Participant, Sweden, give up flying)

For some participants, a solution to deal with the undesirable effects was to resort to medical or professional help. This is the case for some of those who stopped eating meat and flying, who **consult with dieticians, therapists,** and have had regular **medical check-ups** to ensure they stay healthy. Other ways of taking help from others is to reach out and use social networks. The most evident example of this is to **engage in car-sharing communities** to get around. For some participants who have given up flying, one way of maintaining far-away relationships is done by having their friends fly to them instead. Similarly, some participants who have given up car ownership also **rely on others for driving them or their goods** to places. Others have immersed themselves in **new communities** to learn and advocate more about sustainable lifestyles, and some participants **get help from friends and family** to host events. Across the lifestyle changes, participants report gaining new valuable connections by learning to rely more on social networks.

> *"Created "new environment" for myself by attending vegan-friendly events."* (Participant, Germany, give up meat)

Lastly, the participants make use of **virtual and IT solutions** as a way to deal with undesirable effects from their lifestyle change. Among these, the most common is to attend **work meetings and other events online** rather than in person, and to spend more time on the **phone and video communication platforms** to maintain far away relationships. Notably, many participants also expressed how their desire to travel and experience other countries can be satisfied by watching **videos, taking online courses and reading about places and cultures**. As one participant from Hungary noted, *'we don't need to see everything with our own eyes'*.

### Country-specific findings regarding managing social risks

Some case-country specific ways of managing social risks appear from the findings. **Hungary** is the only case-country in which participants challenge norms around the cultural meaning of eating together, and state that they try to not make food the main point of social gatherings. What is more, **Spain** is the only case-country in which no participants report spending more time at home as a way to deal with social risks, while **Sweden** is the only case-country in which no participants report reorganising or reducing personal items as a way to deal with less living space. **Hungary** and **Sweden** are the only case-countries in which participants report using medical or professional help to deal with social risks.

# GENERAL INSIGHTS AND RECOMMENDATIONS

In this section we discuss some general reflections that can be made from the findings about the dominant rebound effects as well as the undesirable and desirable ripple effects. Based on these, we discuss policies and strategies to avoid rebound effects and risks and then suggest short-term actions and long-term strategies. We conclude with suggestions for future research.

## REBOUND EFFECTS IN LITERATURE

Most of the reviewed literature suggests that an average household adopting low-carbon behaviours experience some direct and/or indirect rebound effects (see, e.g. Sorrell, 2009; Gillingham et al., 2016; Freire-González et al., 2017; Font Vivanco et al., 2022). These effects take place through economic (Greening et al., 2000; Sorrell, 2009) or psychological mechanisms (Nelldal & Andersson, 2012; Bauer & Menrad, 2020; Burger et al., 2022) and can erode part of climate impact reductions due to increased consumption of the same primary goods or services or by re-spending the economic savings in other consumption domains.

However, in some consumption domains, indirect rebounds might be higher than the initial environmental gains, if consumer behaviour shifts take place to more carbon intensive goods and services (e.g. consuming less meat but flying more). In extreme cases, also the direct effects might be over 100% (e.g. a backfire effect). This could, for instance, take place among under-consuming households with low environmental awareness, such as, e.g. energy-poor households (Seebauer, 2018) adopting energy efficient technologies (e.g. LED lighting) and producing own renewable energy (e.g. solar PV)(Chakravarty & Roy, 2021).

At the same time, fewer studies are based on empirical evidence and argue that the magnitude of rebound effects is strongly affected by consumers' environmental awareness. For instance, Andersson, D., & Nässén, J. (2023). (2023) concluded that the indirect effects of low-carbon lifestyle choices can actually be negative. This means that adopting these low-carbon behaviours leads to further emission reductions in other consumption domains (except for not flying), where a limited rebound effect was observed. The study explored a sample of environmentally aware individuals and found that the modelling assumptions often made about re-spending generally did not reflect the spending of their empirical sample. In our workshops, we also used samples of individuals who were predominantly more environmentally aware. Judging from the results of our workshops, the indirect rebound effects among our sets of participants are also likely negative.

Overall, the literature on rebound effects tended to focus on economic mechanisms and relied on household spending data. The literature on ripple effects and risks beyond these rebound effects, and in particular empirical research in this area, was less developed.

# EFFECTS IN THE WORKSHOPS

All four of the behaviour changes in the workshops showed the potential for economic savings, but also potential for rebound effects through re-spending. However, this was not equally the case for all participants and even those that did report that the savings from lifestyle changes helped them respond to the rising costs of living or were often re-invested in low-carbon technologies (e.g. solar panels or insulation) - indicative of positive spillover effects.

First, with regard to the undesirable effects, several prevalent themes emerged. These undesirable effects encompass practical, personal, and societal aspects, and some effects can be attributed to all four lifestyle changes that were empirically explored during the workshops. Certain negative effects were more closely associated with specific lifestyle choices.

In general, although to varying degrees, all four behavioural choices required increased effort and planning, implying a certain degree of inconvenience and practical adjustments to daily life, especially initially. The loss of freedom and autonomy tends to be a consequence of all four behavioural changes, manifested as an increased reliance on various external structures, such as public transport schedules or the availability of meat-free alternatives.

Social implications include a less fulfilling social life and a misalignment with common societal norms, which, in turn, can lead to isolation, lower social status, or a sense of burden on friends and family. These characteristics were particularly associated with what was perceived by the society as 'radical unconventional behaviours,' such as giving up eating meat or refusing to fly.

On a personal level, emotional and psychological effects, such as loneliness, alienation, stress, and guilt, as well as a sense of mourning for what has been sacrificed, were recurring themes across the studied behavioural changes. Substitutional behaviours, like cycling or using public transport, can result in safety concerns or physical discomfort (e.g., adverse weather conditions, limited space). Some potential sacrifices may also impact family members and, in turn, lead to feelings of guilt, such as a reduced ability to drive children to activities, go on nature trips, or visit distant family members after giving up personal car ownership.

Lifestyle changes also have significant direct or indirect financial implications. Direct implications frequently include increased spending on substitute consumption of goods and services due to possibly higher prices for substitutes. Indirect implications encompass additional spending on non-substitute goods and services. Such additional expenditures can trigger feelings of guilt and raise doubts about the intended positive impact on climate change. The need for more planning, altered shopping habits, and different consumption patterns can also result in increased consumption of packaging materials due to smaller package sizes or more frequent shopping trips.

The study of behaviour changes also revealed a range of positive and desirable effects.

On a personal level, individuals experienced an increase in their sense of self-worth and took pride in the alterations they made to their behaviour. Adopting a slower and more mindful lifestyle resulted in improved overall quality of life, reduced stress levels, and better health. These changes contributed to enhanced physical and mental well-being, with increased physical activity, healthier dietary choices, and new leisure activities like spending time in natural settings all playing a part. This was particularly evident in how participants indicated they spent their time - it was often in recreational, cultural and community activities.

Moreover, individuals gained new skills and learning opportunities, particularly in areas such as nutrition and cooking, as a result of these behaviour shifts. There was also an increased awareness of the environmental consequences of individual consumption patterns, promoting more responsible choices.

Participants reported using economic savings from the behaviour changes to meet the rising costs from inflation, indicating increased resilience could also be a positive effect.

On a social level, behaviour changes such as carpooling, using public transport, or sharing living spaces fostered stronger community connections and a sense of belonging. In addition, some of the observed changes, like favouring local travel, supporting local businesses, or residing centrally, led to a deeper appreciation for and support of local communities and economies. Importantly, these behaviour changes did not stop at the individual; they had a ripple effect, inspiring others in the person's environment to make similar positive changes in their behaviour.

## INDIVIDUAL WAYS FOR AVOIDING REBOUNDS AND RISKS

Several overarching solutions and strategies emerged from our exploration of how the undesirable ripple effects are being addressed by the workshop participants.

### Conscious consumption and low-carbon practices

Conscious consumption was evident, with participants actively considering the consequences of utilising potential savings elsewhere. They prioritised low-carbon consumption practices, such as opting for organic food, choosing higher-quality items over additional goods, and allocating surplus funds to charitable causes. Many participants embraced environmentally friendly habits focusing on low-carbon activities, such as using trains for travel, engaging in gardening, or cycling. This conscious approach was rooted in their already existing awareness of environmental impacts and their well-informed knowledge.

### Continuous learning and minimalist mindset

Further education and new skills development were also important to stay updated on high-impact climate behaviours. Openness to learning allowed them to be better informed about climate-related issues, potential lifestyle solutions, and, in some cases, the unintended ripple effects. At the same time, some participants noted that they were not aware about the concept of rebound effect before they were engaged in the project's workshops and that now they are more prone to re-think the causes and effects of their lifestyle choices more consciously.

Adopting a minimalist mindset was an important strategy for several respondents who re-evaluated their possessions, reduced cluttering, optimised living space, and prioritised the procurement of multifunctional and/or high-quality items. This approach extended to the deliberate practice of "thinking twice" before making purchases, ensuring that each acquisition was both purposeful and sustainable. This approach is very effective in reducing overall consumption level and if coupled with conscious re-spending strategies could be instrumental in reducing the climate impacts of household consumption.

### Psychological approaches and lifestyle adjustments

Participants frequently employed psychological strategies to better embrace these changes. They focused on the broader positive implications, prioritised quality over quantity, and practised patience with themselves and others. Lifestyle adjustments and adaptations were another effective approach. Participants modified their time management and daily routines, e.g. meal prepping, altering shopping habits, and adjusting recreational and family management activities. Some also reduced their working time to adjust.

### Challenging social norms and community support

Challenging prevailing social norms emerged as a proactive strategy. Participants actively questioned existing norms and encouraged others to embrace similar changes. Otherwise, others opted for avoidance by choosing to steer clear of certain conversation topics or situations that might trigger negative reactions within their social circles. However, the community also played a significant role in mitigating these effects. Many sought out like-minded individuals for support and solidarity during their journey of change.

### Professional help

Seeking professional help was another avenue pursued by some participants. This involved therapy or coaching to better navigate and cope with the challenges arising from behaviour changes.

### Digital technology

Virtual meetings, online events, and digital communication tools also became indispensable for many, both in their professional and personal lives, as they grappled with the challenges brought about by these shifts in behaviour (recent Covid pandemic may have also played an important role in seeking out to others via virtual communication tools).

### Practical living arrangements

Practical changes in living arrangements played a significant role in reducing personal carbon footprints. Many participants highlighted their relocation to more central or urban areas (e.g., closer to work, childcare, shopping, and other services) as the primary reason for no longer needing a car and replacing it with alternative mobility means.

These diverse strategies underscored individuals' dedication to countering rebound effects, managing social risks and promoting sustainable living through a combination of increased knowledge and information, conscious choices, and proactive lifestyle adjustments.

## GENERAL LIMITATIONS

The overview of the workshop insights sheds light on the wide-ranging and impactful benefits linked to the study and adoption of behaviour changes, impacting various facets of both individuals' lives and their communities. However, it is important to acknowledge that these insights stem from empirical data derived from exploring just four lifestyle options and using a relatively small group of workshop participants spanning five countries.

Due to the small sample size, the findings presented in this study should not be treated as statistically significant. Furthermore, the individual lifestyle changes examined were frequently part of broader lifestyle shifts. These shifts are influenced by a variety of personal variables and external factors, making it challenging to isolate the precise causes and effects of the individual actions under study.

It is also important to note that the literature review focussed on rebound effects specifically in this search terms. Without prior knowledge of what types of other ripple effects to search for, a comprehensive and systematic literature review for all types of effects becomes challenging.

However, given that the results are based on identical workshops in five countries with diverse contextual characteristics, the results can be interpreted as indicative to the spectrum of expected ripple effects and cause-effect linkages from lifestyle changes. Therefore, the findings of this study can serve as an empirical starting point, enabling the connection of other effects identified empirically in the workshops back to existing literature.

# CONNECTION TO OTHER WORK PACKAGES

The findings of this Work Package 4 directly relate to previous research findings in Work Package 2 & 3. Part of the objective of this work package was to understand empirically the effects of making significant lifestyle changes. Some of these effects were anticipated by participants in the Work Package 2 citizens in selecting which lifestyle options they would be willing to implement.

Methodologically, some of the validated formats used in the rebound workshops were used by Work Package 2 in the second round of Citizen Thinking Labs. Starting tasks with a short round of individual reflection, guided by provided reflection sheets, and discussing in smaller groups of three to five people were among the workshop formats adopted. The use of recordings of the day to support documentation, which had proved useful in the follow-up to the rebound workshops, was also adopted.

Participants in the Work Package 4 workshops also reiterated that individual changes and effects are strongly influenced by structural changes, the focus of Work Package 3 of the project. In the expert Interviews in that work package, 36 case country and international experts suggested that there is an imperative need for systemic change, highlighting the interdependence of various societal structures to counter the inherent "rebound" dynamic of the economic growth paradigm as the most important barrier to change. Experts highlighted that transformative shifts should encompass multiple facets, including social relations, property relations, political priorities, and economic incentives, to bring about comprehensive change (as also reflected in this report). The experts furthermore highlighted the importance of grassroots movements, civil society engagement, and citizen participation as catalysts for change, emphasising the pivotal role of political will and a collective shift in consciousness, which is also highlighted in this report, as confronting deep societal structural barriers and challenges in achieving 1.5° lifestyles is required.

As part of the first Stakeholder Thinking Labs in Work Package 3, stakeholders in the five case countries also highlighted the need for systemic changes in the different consumption fields to promote sustainable and welfare-focused sufficient consumption. The stakeholders suggested a combination of policy measures, especially taxes and bans, public education and cultural shifts. The discussion around taxes and bans, while not necessarily directly reflecting on rebound effects in each case country, was often based on the understanding that fairness, equity, societally set limits coupled with shared service provisioning were needed for large-scale public acceptance of changes. These outcomes were the starting points of discussion for the subsequent EU Stakeholder Thinking Lab, where the challenge of overcoming the "rebound" of economic growth was a central focus, and will continue to guide the second, decentralised case country Stakeholder Thinking Labs. In these labs, the focus will be on discussing how to overcome structural barriers to 1.5° lifestyles in 6 key cases, including a discussion with the stakeholders on rebound effects.

# POLICY ACTIONS AND STRATEGIES FOR AVOIDING REBOUNDS AND RISKS

How any savings are re-spent is also key to limiting rebound effects and other negative environmental ripple effects. In general, the findings suggest that when efficiency measures lead to cost savings, the savings should be spent on higher-quality goods or services with lower carbon impacts to avoid rebound. Wiedenhofer et al. (2018) suggest savings should be directed towards low-impact categories and Albizzati et al. (2022) further specify these as health, education and cultural activities, which they note also have positive social impacts. This is similar to the findings of Claudelin et al. (2020), namely that "impact investing" can be an effective measure to reduce rebound. It has the added benefit of increasing the GHG mitigation potential of the first action (i.e., a negative rebound effect).

Recommendations for decreasing rebound effects mainly target policies that make potential rebounds more expensive (e.g. by making air travel more expensive through reduction of subsidies and/or application of taxes) or shifting consumption to higher quality (and usually more expensive) products, for example, local organic food or clothing (Hertwich, 2005).

Research has also suggested that subsidies on high greenhouse gas-emitting consumption, such as meat, should be eliminated. In their place, subsidies could be directed toward lower-impact alternatives, such as ecologically produced and organic foods (Schanes et al., 2016). However, such financial incentives to encourage behaviour change should be used with caution, as the economic support provided to achieve the behaviour change can lead to rebounds themselves (e.g. Font Vivanco et al., 2016 found that bonus-malus schemes can lead to rebounds if the taxes and subsidies are not set at the right levels or target adequate goods and services).

Working less was a strategy given some attention in the literature (e.g. Wiedenhofer et al., 2018) as a key strategy for limiting rebound effects in particular. Reduced income emerged as an active choice to work less for some participants in the workshops and others saw potential in this as a strategy (but had not done this themselves). In general, participants in the workshops were positive when describing how they spent any increases in time, with many spending more time in nature, gardening, cooking, socialising, hobbies, and education. This aligns with the findings of Wiedenhofer et al. (2018), which suggest that reduced work and income can lead to smaller carbon footprints and fewer rebound effects, particularly if the additional free time is spent on less carbon-intensive well-being activities like caregiving and community involvement. However, Wiedenhofer et al. (2018) also emphasise that it is important to note that reduced working hours needs to be accompanied by consideration of those already living on low incomes and in combination with protecting social policies to ensure workers' ability to satisfy basic needs.

Reduced income is also influenced by macroeconomic factors such as high inflation, elevated

food costs, and expensive property prices in urban areas, all of which contribute to an increased cost of living. While theoretically similar to policy recommendations found in literature that advocate for taxing consumption—like carbon pricing or energy taxes—to limit re-spending and overall rebound effects (Freire-González & Ho, 2022), there is a key distinction. Inflation impacts consumption broadly, whereas targeted taxes can more precisely steer behaviour toward sustainable consumption. It's also crucial to consider the distributional effects of such taxes and how the generated revenue is reinvested in low-carbon strategies at the policy level (Font Vivanco et al., 2016).

Pro-environmental values can be associated with reducing and avoiding rebound effects (Andersson & Nässén, 2023). In the workshops, these values made individuals more conscious of the carbon impact of various behaviours, thereby discouraging further investment of time and money into high-carbon activities. Workshop participants also had a general preference for low-carbon behaviours. Generally, behaviours that can be classified as 'experiences' and even more so as 'learning' are comparatively low-carbon and an interest in such behaviour makes it more likely that rebounds can be avoided. Of course, a general de-acceleration of a lifestyle, with more time spent sleeping, relaxing, or personal care, also helps to prevent rebounds.

Elf et al. (2019) also suggest that for behaviour changes to result in spillover effects and wider lifestyle changes, individual households also need to be part supported so that behaviours are maintained over time. The authors note the need for structural support (e.g. energy and transport systems) but also social support in the form of communities where experiences are shared and individuals supported in their lifestyle changes. Community support was also mentioned by workshop participants as an enabling strategy. WIthout supporting communities and infrastructure, Elf et al (2019) found that behaviour changes were not always maintained, despite pro-environmental attitudes and identities.

In the workshops, some of the perceived negative effects from low-carbon behaviour changes are clearly linked to the behaviour change being niche and unfamiliar. This relates to additional time needed to adjust to a new behaviour (e.g. learning new recipes, learning to navigate public transport, finding new social groups), but also to the feeling of being an "outsider" at the fringes of society. Policy-making that supports such adjustment processes, or helps to protect the niche until it is making the jump to mainstream can significantly help to avoid such temporary negative effects from low-carbon behaviour changes and increase the likelihood that those having made the transition stick with it and help grow the niche into becoming mainstream enough.

There are several low-behaviour changes in our study that also came with co-benefits such as better health or less stress. Such co-benefits should be taken advantage of in policy-making, not least related to health issues, as there are strong public health arguments to support some behaviours that also lower carbon emissions (see e.g. Mózner & Csutora, 2013). Co-benefits

can be utilised more in framing informative and other policy instruments as well. Amelung et al. (2019) found that communicating about health benefits, particularly in relation to the nutrition and leisure domains can increase the acceptability and adoption of lifestyle changes.

It is important to also note that rebound effects can be associated with development and well-being (Makov & Font Vivanco, 2018). Lower-income households may not be consuming at levels desirable for their well-being. For example, heating can be associated with positive health impacts by allowing energy-poor households to heat to their preferred temperature (Seebauer, 2018). It has been suggested that rebound measures should first and foremost target high-income households (Murray, 2013).

From a macroeconomic perspective, Lange and Berner (2022) find that economic growth and rebound are strongly related and they calculate a growth-related rebound of 20% and 47% overall. They suggest that avoiding rebound has a trade-off with economic growth and they argue for "policies beyond green growth in order to bring about the reductions in energy consumption needed to achieve climate change targets" (Lange and Berner, 2022, p.7).

## Short term actions

### Support niche communities in trying out and adopting more climate friendly lifestyles

Supporting niche communities in experimenting with and adopting more climate-friendly lifestyles is a pivotal strategy for avoiding the negative effects of feeling isolated. Being part of communities was perceived as a way of connecting to others as well as a way to share experiences and knowledge to make lifestyle changes easier and more accepted.

Municipalities can play a crucial role in nurturing these niche communities by providing the necessary resources such as space, funding, and expertise (Voytenko Palgan et al., 2021). For instance, local governments could allocate land for community gardens, renewable energy projects, or even entire eco-villages. Financial support could be offered in the form of grants or subsidies to encourage sustainable practices like waste reduction, energy efficiency, or local food production.

Additionally, municipalities can assist in raising awareness about these communities and their initiatives, thereby inspiring a wider audience to adopt similar practices. This could be achieved through public awareness campaigns, educational programmes, or partnerships with local media. The lessons learned from these niche communities can then be scaled up and applied in more mainstream settings, accelerating the societal transition to 1.5° lifestyles. In this way, niche communities act as catalysts for change, providing both the inspiration and the practical know-how to make sustainable living a reality for the broader population.

### Enhance and support consumers' digital literacy

Participants in our workshops often explained how they adopted Information and Communication Technology (ICT) as a means to stay in touch with their network, and replicate or substitute real-world experiences they were not any longer able to pursue. However, to adopt technology as a replacement for high-carbon behaviours such as flying requires both the hard- and software to facilitate such solutions, but also the knowledge and confidence to use it. Depending on age, educational background, familiarity with technologies, etc. the use of existing and emerging technological solutions can be challenging for individuals, with the risk of the experience becoming frustrating and negative. With increased digitization, the necessity to be able to navigate a large number of hard- and software solutions becomes ever more important. To enable a swift and successful transition to digital low-carbon solutions as a replacement for high-carbon behaviours, digital literacy is essential. To support digital literacy for various societal groups - in particular such that currently might lack being - should be considered a 'low hanging fruit' for policy-makers in supporting such a transition.

### Provide information about lifestyles changes

The provision of accurate and accessible information is crucial for supporting those making lifestyle changes to not only avoid rebound but also negative effects in needing to find information for themselves. Various channels can be employed to disseminate this information effectively. Traditional media outlets, such as newspapers and television, can offer broad coverage, while social media platforms can target specific demographics and foster community engagement. Educational institutions, from schools to universities, can integrate sustainability into curricula, thereby instilling these values from a young age. Governments can launch public awareness campaigns and provide guidelines or toolkits for sustainable living. This can include information about nutrition and cooking without meat, using public transport, and other low carbon transport alternatives. Businesses also have a role to play, particularly those in the retail and service sectors, by offering transparent information about the sustainability credentials of their products or services. Non-governmental organisations and community groups can offer campaigns, workshops, webinars, and other educational resources, often tailored to local needs. By leveraging a multi-channel approach that involves a diverse set of actors, the reach and impact of information provision can be maximised, thereby accelerating the transition to 1.5° lifestyles.

### Promote positive narratives and communicate co-benefits

Given the experience of isolation and being an outsider among many participants adopting low-carbon lifestyle changes, as well as the accounts of new communities and appreciation being an important support structure for achieving lasting low-carbon behaviour changes, policy-makers are well-advised to intensify communication that strengthens positive narratives for such behaviour changes. Storytelling and framing are tools to increase appreciation in society

for certain behaviours. Furthermore, such communication should highlight the co-benefits from a low-carbon lifestyle, such as better health, improved fitness, increased wellbeing, and stronger social bonds, in order to provide additional positive arguments for a low-carbon behaviour change.

### Financial incentives and support

Even in the short term, municipal and national governments can support citizens directly, e.g. with subsidies for purchase of electric bicycles, etc. However, as noted throughout this report, such subsidies should be used with caution and with complementary information or policies to support re-spending savings on other low-carbon activities and consumption. However, taxes in general can be used to steer consumption and have the effect of reducing consumer spending. Then it is the public re-spending from the public revenues raised that should be considered carefully for additional low-carbon investments.

### Support professional health services

Supporting professional health services is a vital component in helping people adjust to lifestyle changes and any negative effects while promoting the positive effects of 1.5° lifestyle changes. In the short term, before norms are changed and niche communities become mainstream, there may still be negative effects for early adopters. Health services can play a dual role in both reducing their own carbon footprint and promoting sustainable, low-carbon choices among the population. A focus on preventative medicine, rather than cure, aligns well with this approach. Preventative measures such as regular exercise, balanced diets, and mental well-being not only reduce the need for more resource-intensive treatments but also encourage lifestyles that are inherently more sustainable. Thus, health professionals can incorporate sustainability into their patient care models, which could include nutritional guidance that favours plant-based diets, exercise regimes that encourage walking or cycling over car use, or mental health services that promote well-being through meditation, yoga practices, and nature-based therapies. In addition, healthcare providers can adopt sustainable practices in their operations, from waste management to energy use, thereby setting an example for other sectors.

### Encourage consumption of services and education with lower carbon impacts

In considering re-spending patterns to limit rebound effects, encouraging the consumption of services and education with lower carbon impacts is a strategic imperative. Fiscal measures such as adjustments in Value Added Tax (VAT) can be highly effective in steering consumer choices towards more sustainable options. For example, Sweden has taken steps to encourage reuse over recycling by reducing VAT on repairs of bicycles, shoes, leather goods, clothing, and household linens. Similarly, reducing VAT on low-carbon services like public transportation, sharing services, or education on sustainability can make them more financially accessible to the general public. Conversely, increasing VAT on high-carbon impact services can serve as a

deterrent, nudging consumers away from unsustainable choices. This dual approach not only incentivises individual behaviour but also signals to industries and service providers the need to innovate and offer more sustainable options. By aligning economic incentives with sustainability goals, such fiscal policies can accelerate the transition to 1.5° lifestyles, making low-carbon services and education both more attractive and more attainable for a broader segment of the population.

## Long term strategies

### Reframe and change societal norms and narratives

Minimising negative effects from 1.5° lifestyle changes necessitates a profound shift in social norms because prosperity extends beyond material consumption to encompass a good working life, close and meaningful relationships, opportunities for self-realisation, and participation in society. In a 1.5° lifestyle, status must be decoupled from material excesses and instead be associated with the non-material value of a person, such as the quality of their relationships with others or contribution to community. Changing values and norms is also critical for reducing rebound effects since they define how money and time saved from pro-environmental measures, e.g., shifting to vegan diet, giving up private cars or moving to a smaller house, will be (re-)spent. Changes in norms can facilitate the transition to 1.5° lifestyles if it becomes more acceptable to be content with fewer material goods than what is considered normal today, as well as with goods that are bought second-hand or repaired (Spangenberg & Lorek, 2019). Norms for using immaterial social and collective goods can also facilitate the reconstruction of the good life with much less sustainability impact. Such norms can make it more acceptable to be content with fewer material goods, to engage in collaborative consumption, and to participate in community-based initiatives like the voluntary simplicity movement, repair cafes, and urban farming. Vegetarian diets can be normalised by introducing vegetarian meals in schools, at public events, conferences and official meetings. Changing norms is a long-term endeavour, but many actors play critical roles in the process, from schools and universities to societal and civic movements, to advertising and actions of businesses and public sectors, and to arts and the media. It involves the revitalisation of citizenship and continuous social learning.

### Education and skills

The transition to 1.5° lifestyles necessitates not only awareness but also the acquisition of new skills and habits. This makes it vital to offer assistance in 'learning a new lifestyle' and 'developing the necessary skills to support it.' This is especially important in educational settings, where the foundation for lifelong habits is often established. Introducing skills for a low-carbon lifestyle into pre-school, school and university curricula can provide the younger generation with the practical knowledge they need to make sustainable choices. These skills could range from understanding the basics of energy efficiency and waste reduction to more complex topics such as circular economy principles and sustainable supply chain management.

Practical skills are also needed, for example, in extending product lifetimes through repair and refurbishment. Similarly, mending or upcycling clothes could be valuable skills for promoting low-carbon lifestyles, as well as growing food or producing one's own electricity in a school yard. Professional education should incorporate sustainability training to enable those already in the workforce to adapt to the changing demands of a low-carbon economy. By embedding these skills into educational frameworks at all levels, we can ensure that sustainable living becomes second nature, rather than a lifestyle choice requiring constant effort and conscious decision-making.

### Infrastructure/structural changes

Infrastructure not only enables but also standardises sustainable behavioural choices and can help reduce rebound effects of some behaviours by enabling low-carbon alternatives for time and spending. For instance, shared living projects prioritise smaller individual living spaces while enlarging communal areas, for e.g., communal cooking, shared libraries and mobility hubs, thereby fostering social cohesion and reducing individual material consumption. The availability of charging stations can act as a catalyst for the adoption of electric cars, thereby addressing a significant bottleneck in the transition to sustainable transportation (Schulz & Rode, 2022). Limiting parking spaces can further dis-incentivise car use (Iseborn et al., 2021). Similarly, well-designed public transport systems, along with cycling and walking paths, can make sustainable mobility options more accessible, quick, and cost-effective. This, in turn, can reduce some of the negative effects currently experienced with inconvenient and expensive public transport alternatives to flying and car use. The development of reuse and sharing infrastructures like reuse centres, tool and toy libraries, and repair cafes can foster circular consumption, thereby increasing societal self-sufficiency and long-term resilience. Therefore, a multi-faceted approach to infrastructure is essential for the realisation of 1.5° lifestyles, involving targeted policy instruments, technological innovations, and community-based initiatives.

### Change economic incentives

Economic instruments play a pivotal role for supporting low-carbon behaviours and dis-incentivising high-carbon lifestyles. Some are already implemented in the EU, including the EU ETS, but they could be more broadly and ambitiously implemented to enable and support 1.5° lifestyles (Dalhammar et al. 2022). Well-designed economic instruments such as taxes are argued to be essential for avoiding rebounds (Freire-Gonzalez & Ho, 2002: Font-Vivanco et al., 2016). Additionally, some countries have reduced or abolished VAT for sharing and repairs, offer tax deductions for repairs, or have implemented bonus-malus systems for vehicles and products, as well as repair vouchers for consumers. However, reduced prices on sustainable alternatives may lead to rebound effects, i.e., savings supported by these economic instruments can be spent on less sustainable alternatives elsewhere, e.g., flying. Thus the importance of sustainability-oriented norms cannot be overstated. Here public procurement policies that favour renewable energy, and reusable or remanufactured products can be

instrumental for directing public spending towards low carbon and sustainable technologies. New ideas for economic instruments that are currently under discussion but not yet implemented are levies or taxes on meat and sugar (see e.g. Dalhammar et al., 2022). The concept of trading individual carbon quotas is also being explored that would also effectively limit citizen's rebound by limiting carbon footprint(see Dijkshoorn, 2019).

**Support economic development towards 'localization' and digitalisation**

Localisation or distributed economies aim to reduce the carbon footprint by shortening the distance between producers and consumers, thereby decreasing transportation emissions, and increasing reliance on self-sufficient communities. Localisation encourages the growth of local economies through the promotion of local food production, renewable energy projects, and circular economies that minimise waste through reuse and recycling. Beyond environmental benefits, localisation also fosters social cohesion by strengthening community bonds, thereby creating a supportive environment for sustainable living practices. For instance, local food systems can more readily adopt sustainable farming methods and sharing of agricultural machinery, while local energy systems can be tailored to utilise renewable resources available in the vicinity. Furthermore, localisation could involve equipping individuals with the skills needed to thrive in a low-carbon, local economy, such as farming, repair and upcycling or maintenance of renewable and distributed energy systems. By prioritising localisation, communities can become more sustainable and resilient to various shocks.

Digitalisation can further enhance localisation efforts by making local systems more efficient, connected, and agile. For example, digital platforms can facilitate local food sharing, community-based renewable energy projects, or even local circular economies where goods are exchanged, reused, or upcycled within the community. However, it is important to be mindful of the social and psychological consequences of increased digitalisation. While digital tools can make local systems more efficient, they can also lead to issues like social isolation or mental health challenges if not managed carefully. Therefore, digitalisation should be implemented mindfully and purposefully to enhance community interaction rather than replace it, perhaps by using digital platforms to facilitate real-world community engagement and activities. Further consideration is the energy consumption of digital infrastructure itself - it should align with the low-carbon goals of a 1.5° lifestyle. This could involve powering data centres with renewable energy or implementing energy-efficient digital technologies.

## FUTURE RESEARCH

Our work in Work Package 4 of the EU 1.5° Lifestyles project underscores the importance of moving beyond a narrow focus on economic rebound effects to fully understand the complexity of negative and positive ripple effects caused by low-carbon behaviour changes, as well as the moderating factors for such effects. Furthermore, it has opened up several potential avenues for future research.

While the analysis in this work package is not exhaustive, it nonetheless offers valuable insights into the diversity and intricacy of the ripple effects resulting from lifestyle adaptations aimed at addressing climate change. These findings underscore the significance of considering these multifaceted impacts when formulating climate policies. The study, despite its limitations, contributes valuable perspectives to the ongoing discourse on sustainable development and environmental policy-making. It builds upon the concept of ripple effects to empirically identify these from an individual lifestyle perspective. The findings can be a starting point for future research.

First, we encourage a more systematic approach to understanding ripple effects. This approach would ensure that so-far overlooked, yet critical aspects of rebounding are captured. By unpacking various ripple effects, we can better understand how low-carbon behaviour changes influence an individual's lifestyle and well-being. This understanding will aid in developing effective measures to address any undesirable consequences that may arise.

Second, both our results and a small selection of other studies (e.g. Anderson & Nässén, 2023) indicate that individuals with strong pro-environmental values and an understanding of rebound effects exhibit behavioural outcomes that are contrary (i.e. lower) to the patterns observed in most studies (i.e., lower rebound effects). Further examination of the role of these pro-environmental values in determining the extent of the rebound effects is warranted. In this respect, it is also important for future research to confirm this observed effect of pro-environmental behaviour with more representative data. There is a compelling case for further quantitative examinations of this phenomenon.

Our study has only initiated exploration into strategies employed by participants to amplify the positive effects of their lifestyle changes. Future research should be structured to elicit insights not only on mitigation of undesired outcomes but also on the enhancement of beneficial spillovers. Such knowledge will support the shaping of effective policy interventions for promoting low-carbon lifestyles.

In conclusion, as the EU embarks on its transition towards a low-carbon future, it becomes increasingly crucial to understand the intricacies of behaviour change. A comprehensive understanding of these nuances will be pivotal in ensuring that interventions yield the desired lifestyle changes.

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# APPENDIX

Table 9. The final coding structure with general themes, codes, sub-codes and the key themes and the examples these produced, specific to lifestyle change.

| General themes | Codes | Sub-codes | Key themes and examples |
|---|---|---|---|
| **Reasons for lifestyle change** | Valued-based reasons | Environmental reasons<br><br>Ethical reasons | • beliefs and values<br>• environmental considerations and/or the climate crisis<br>• empathy and fairness<br>• align with self-image |
| | Practical reasons | Convenience reasons | • changed personal needs e.g.<br>  ○ family growth<br>  ○ moving in with new partner<br>  ○ moving closer to city |
| | Economic reasons | | E.g. car ownership expensive |
| | Structural reasons | | • well functioning public transport system<br>• limited access to larger accommodation<br>• teleworking |
| | Health reasons | | E.g give up meat to feel healthier or due to allergies or digestive disorders |
| | Social reasons | | • being influenced by friends and other people around |
| **Undesirable ripple effects** | Less freedom | Feeling limited<br><br>Less freedom of choice<br><br>Less privacy<br><br>Physical constraints<br><br>Dependence on others<br><br>Dependence on structures<br><br>Less spontaneity<br><br>Less time in nature | *No flying*<br>• missing out on cultural exchanges and knowledge<br>• bound to choose local travel destinations or means of transport<br>*No car*<br>• having to adapt to public transportation and infrastructure and timetables<br>• spontaneous trips to nature more difficult<br>*No meat*<br>• limited availability of vegetarian/vegan options<br>*Living smaller*<br>• Less privacy |

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| | Negative social effects | Strain on social identity<br><br>Negative change for social relationships<br><br>Less visits and time with family and friends | *No flying*<br>● having to turn down social events<br>● giving up relationships<br>● conflicts of ethics<br>*No car*<br>● not being able to do favours<br>● feeling like a burden and being dependent on others<br>● impact on social status<br>*No meat*<br>● conflicts<br>● refrain from social interactions<br>*Living smaller*<br>● seeing friends and family less often<br>● lacking space for socialising at home |
| | Difficult management | Increased travel time<br><br>Extra efforts<br><br>Less certainty<br><br>Risking being late | *No flying*<br>● increased travel time<br>*No car*<br>● longer travel time<br>● planning and information gathering regarding timetables, routes and transfers<br>● uncertainty<br>● opportunities for transporting goods and groceries disappear<br>*No meat*<br>● additional efforts to sustain meat free diet<br>● spending more time on cooking and meal planning<br>*Living smaller*<br>● lack of living and storing space<br>● additional effort to optimise and plan their home |
| | Mental discomfort | Stress<br><br>Sadness and less joy<br><br>Fear and less security<br><br>Loneliness<br><br>Frustration<br><br>Shame<br><br>Hopelessness | *No flying*<br>● bus, car and cycling feel less safe<br>● sadness and grief<br>● guilt when flying for work<br>● feel lonely<br>*No car*<br>● feelings of danger and insecurity<br>● feel more exposed<br>*No meat*<br>● having to bring your own food<br>● social exclusion<br>● being misunderstood<br>● defend and prove oneself<br>● feelings of not doing enough<br>*Living smaller*<br>● feeling of confinement<br>● worsened mood<br>● conflicts with family members or neighbours |

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| | Physical discomfort | Freezing/sweating<br><br>Less sleep<br><br>Noise | *No flying*<br>● public transportation do not match the convenience and comfort of flying<br>*No car*<br>● negative effects of local weather conditions<br>● unhygienic setting<br>*Living smaller*<br>● less peace and quiet<br>● more noise<br>● negative effects on sleep |
| | Worse health | | *No car*<br>● more frequent colds<br>● inhaling exhaust fumes<br>*No meat*<br>● (initially) negative health effects<br>*Living smaller*<br>● worse air quality |
| | Increased expenses/loss of income | | *No meat*<br>● meat substitutes more expensive<br>*Living smaller*<br>● unplanned, often more expensive shopping<br>● not being able to shop discounted items in bulk |
| **Desirable ripple effects** | Positive spillover | Staying and consuming locally<br><br>Sustainable transport<br><br>Engage in sharing and circular activities<br><br>Increased knowledge<br><br>Sustainable food<br><br>Less waste<br><br>Anti-materialism<br><br>More time in nature<br><br>Sustainable energy<br><br>Less cleaning and use of chemical products | *No flying*<br>● hiking and biking more<br>● experience local nature<br>● energy efficient renovations<br>● supporting the local community and economy<br>*No car*<br>● relocate to areas with access to low-carbon mobility infrastructure<br>*No meat*<br>● increased knowledge of meat free diets<br>● increased awareness of climate intense behaviours<br>● new food related consumption patterns<br>● generally less consumption<br>*Living smaller*<br>● consuming less and decluttering<br>● donating still usable items<br>● sharing appliances<br>● using less cleaning and maintenance products<br>● less waste<br>● better access to low-carbon mobility infrastructure<br>● promoting community and neighbourhood life<br>● energy efficiency renovations<br>● organic and healthy food |
| | Mental comfort | Satisfaction<br><br>Less stress<br><br>Feeling more free | *No flying*<br>● strong sense of pride and role model<br>● quality of journey changed for the better<br>● feel more relaxed and present when travelling<br>*No car*<br>● decreased level of stress |

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| | | Pride<br><br>More quality alone time | ● more satisfied with life and values<br>● liberating feeling<br>*No meat*<br>● increased self-confidence<br>*Living smaller*<br>● more free time<br>● more time available for leisure and hobbies<br>● increased quality of life |
| | Positive social effects | | *No flying*<br>● stronger relationship with family and others in local area<br>*No car*<br>● able to interact with new people<br>*No meat*<br>● influencing family and friends<br>*Living smaller*<br>● quality time with friends and family |
| | Better health | | *No flying*<br>● increased mental and physical well being<br>● Invest in a healthier lifestyle<br>*No car*<br>● more active lifestyle<br>● spending savings on exercises and healthier food<br>*No meat*<br>● feeling healthier<br>*Live smaller*<br>● positive health effects |
| | Cost savings | | *No car*<br>● not spending money on car maintenance and fuel<br>*Live smaller*<br>● lower expenses for e.g energy and rent |
| **Mitigating rebound effects** | Conscious consumption | | ● general mind-set of "climate awareness"<br>● actively restrict what they believe to be carbon-intense activities, e.g.<br>○ travel less (far)<br>○ avoid resource-intense food<br>○ avoid certain transportation modes (e.g., flying)<br>○ not make any spontaneous purchases<br>● actively increase what they believe to be low-carbon activities, e.g.<br>○ buying more healthier and/or organic food<br>○ making energy efficiency renovations at home<br>○ travelling by train, bus or bike<br>○ donating, saving or investing surplus money |
| | Conscious spending of time | New hobbies and leisure activities<br><br>Low carbon employment | ● being more outdoors<br>● gardening<br>● growing food<br>● going on walks and bike-trips<br>● working less<br>● working more from home<br>● online meetings |

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| | | | • information/education |
| | Structural and physical enablers | | E.g. no room or need for having a car |
| | No net cost or time savings | | • travelling by public transport takes more time<br>• expensive vegetarian diet<br>• increased electricity prices<br>• high inflation rate |
| **Managing social risks** | Accept | Got used to change over time | • accept challenges<br>• tolerance and patience increase<br>• learning to live with changes<br>• focus on positive |
| | Plan and reorganise time | New shopping behaviours<br><br>New eating patterns<br><br>More time outside<br><br>More time at home | • changing the way grocery shopping is planned<br>• eating before going to events<br>• bring own food<br>• change the timing of certain activities at home<br>• change where time is spent |
| | Reorganise and reduce personal belongings | | • reevaluating items<br>• increasing utility of items |
| | Change others | | • activism<br>• discussions<br>• citizen participation |
| | Challenge norms | | • challenging cultural norms<br>• challenging mobility norms |
| | Avoid | | • conversation topics, situations, and/or people |
| | Medical or professional help | | • consult with dietitian<br>• consult with therapist<br>• medical checkups |
| | Social networking | | • engage in car-sharing communities<br>• rely on other for driving them or their goods<br>• new communities<br>• help from family and friends |
| | Virtual and IT solutions | | • attend work meeting and other events online<br>• using phone and video communication platforms<br>• videos, taking online courses and or/reading |

Table 10. The total number of participants per lifestyle option and case-country, their responses to the individual reflection questions and the comparison between these and the number of responses coded as pioneers.

| | Responses first question | Responses second question | Responses third question | Responses fourth question | Participant responses coded as pioneers/Total # participants |
|---|---|---|---|---|---|
| **Sweden** | | | | | **17/17** |
| No flying | 5/5 | 4/5 | 5/5 | 4/5 | **5/5** |
| No car | 4/4 | 4/4 | 4/4 | 4/4 | **4/4** |
| No meat | 4/4 | 4/4 | 4/4 | 4/4 | **4/4** |
| Live smaller | 4/4 | 3/4 | 4/4 | 4/4 | **4/4** |
| **Latvia** | | | | | **19/19** |
| No flying | 4/4 | 4/4 | 4/4 | 4/4 | **4/4** |
| No car | 5/5 | 5/5 | 5/5 | 5/5 | **5/5** |
| No meat | 5/5 | 5/5 | 5/5 | 5/5 | **5/5** |
| Live smaller | 5/5 | 4/5 | 5/5 | 4/5 | **5/5** |
| **Germany** | | | | | **11/12** |
| No flying | 3/3 | 3/3 | 3/3 | 3/3 | **2/3** |
| No car | 3/3 | 3/3 | 3/3 | 3/3 | **3/3** |
| No meat | 3/3 | 3/3 | 3/3 | 3/3 | **3/3** |
| Live smaller | 3/3 | 3/3 | 3/3 | 3/3 | **3/3** |
| **Hungary** | | | | | **16/17** |
| No flying | 3/5 | 5/5 | 5/5 | 3/5 | **5/5** |
| No car | 4/4 | 4/4 | 4/4 | 4/4 | **3/4** |
| No meat | 4/4 | 4/4 | 4/4 | 4/4 | **4/4** |
| Live smaller | 4/4 | 4/4 | 4/4 | 4/4 | **4/4** |
| **Spain** | | | | | **15/19** |
| No flying | 4/4 | 4/4 | 4/4 | 4/4 | **2/4** |
| No car | 5/5 | 5/5 | 5/5 | 5/5 | **3/5** |
| No meat | 5/5 | 5/5 | 5/5 | 5/5 | **5/5** |
| Live smaller | 5/5 | 5/5 | 5/5 | 5/5 | **5/5** |