Behavioural Climate Change Mitigation Options and Their Appropriate Inclusion in Quantitative Longer Term Policy Scenarios

Main Report

Report
Delft, April 2012

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Preface

This is the final report under the contract *Behavioural Climate Change Mitigation Options and Their Appropriate Inclusion in Quantitative Longer Term Policy Scenarios*, European Commission, DG Climate Action contract 070307/2010/576075/SER/A4. The study has been conducted by a consortium led by CE Delft comprising of Fraunhofer ISI and LEI.

Next to this main report, four separate reports have been issued, to which this report references where appropriate:
1. The Transport Domain Final Report.
2. The Housing Domain Final Report.
3. The Food Domain Final Report.
4. A Technical Report on the appropriate inclusion of results of the analysis in model-based quantitative scenarios.

Together, the five reports constitute the final delivery under the contract.

Jasper Faber

Contents

Summary

Changes in behaviour of households and consumers can result in large reductions of greenhouse gas (GHG) emissions in the EU, both in the shorter and in the long term.

This study has focused on emission reduction potentials not covered by the EU Emissions Trading System and identified 36 options for behavioural change in the mobility, housing and food domains that will, when realised, result in a decrease of GHG emissions. Of these options, 11 have been studied in detail. If implemented by all the households and/or consumers which can reasonably be expected to be able to do so, their impact on EU GHG emission mitigation potentials would range from 22 Mt CO_2 in 2020 (a reduction of space heating temperature by 1°C) to more than 250 Mt CO_2 in 2020 (a shift to a vegetarian diet). Table 1 provides an overview of the maximum realistic mitigation potential of the changes in 2020, 2030 and 2050.

Table 1 **Maximum realistic mitigation potential of behavioural changes, relative to PRIMES/GAINS reference scenario projections**

Behavioural change	2020	2030	2050
1a. Buying and using an electric car	96-174	330-371	420-462
1b. Buying and using an plug-in hybrid	56-113	198-286	251-354
2. Buying and using a smaller car	80-96	74-88	71-84
3. Fuel efficient driving style	47	32	10
4. Teleworking	35-45	38-47	40-49
5. Virtual meetings	39	35	55
6a. Reduction of room temperature by 1°C	22	19	16
6b. Reduction of room temperature by 2°C	45	38	32
7. Optimised thermostat settings	11	10	9
8. Optimised ventilation behaviour	43	42	<<42
9. Shift to a vegetarian diet	266	270	271
10. Reduction of animal protein intake (one animal protein-free day per week)	50	50	50
11. Shift to a healthy diet	200	203	204

Note: The maximum realistic mitigation potential is defined as the reduction in GHG emissions achieved when the option is adopted by the largest number of actors possible, taking into account realistic and structural constraints, and where possible indirect effects and rebound effects.

For each of the selected behavioural changes, barriers have been identified that inhibit their implementation. Often, these barriers are specific to the change options, although a generalisation is possible per domain. Policies can overcome barriers to an extent. This study has also identified policies and for

a selection of change options quantified the likely effects of policy packages aimed at overcoming barriers.

In the transport domain, changes in car purchase and use behaviour are mainly held back by social and psychological barriers, such as preferences for conventional cars, challenges to mobility related lifestyles and the image of a car, although other types of barriers may also be relevant. In the case of electric vehicles, economic barriers are also important as these cars have high initial costs. Teleworking and virtual meetings are mainly held back by social/psychological (e.g. fear for social isolation and adverse impacts on careers) and institutional (lack of support from managers/organisations) barriers.

A wide variety of policy instruments could be implemented to address the barriers related to the mobility related behavioural changes. In this study we assessed the effectiveness of specific policy packages for two behavioural changes in transport: buying and using smaller cars and teleworking. The policy package with regard to smaller cars consists of economic and regulative instruments supported by informational measures. The maximum abatement potential of this policy packages was estimated at 6-9% of the CO_2 emissions per pkm. This would correspond to 24–35 Mt in 2050. It should be noted that these reduction potentials depend to a large extent on tax incentives, which would require unanimity amongst Member States to be implemented at an EU level, and whose effect may not be fully realised due to interactions with the existing CO_2 and cars regulation.

The policy package with respect to teleworking consists of a wide variety of measures, including economic, regulative, informational and procedural instruments. There is little empirical evidence to build upon in an assessment of the effectiveness of this package. Our estimate suggests that about a fifth of the maximum realistic mitigation potential can be achieved, which amounts to 7 – 9 Mt CO_2 in 2020 and increases to 8 – 10 Mt CO_2 in 2050. Note that these estimates have a large range of uncertainty.

In the housing domain, the most important barriers towards residential energy saving related to use behaviour are limited cognition, as lack of knowledge and awareness about one´s own energy consumption.

To address the barriers a policy package consisting of informational and regulative instruments as well as subsidies and energy taxes has been defined. The empirical evidence on the effectiveness of policies is limited, and there is no evidence on the effectiveness of packages. Extrapolation from a few case studies suggests that reductions up to a quarter of the maximum potential are achievable in the short run, increasing to about a third after a few decades. For a reduction in room temperature of **1°C,** this corresponds to a reduction in emissions of 19 Mt CO_2 in 2020, increasing to 22 Mt CO_2 in 2050.

In the food domain, the most important barriers are a lack of knowledge on the environmental or health impacts of food products and the strong cultural norms that affect dietary choices. Moreover, diets have a strong habitual component.

To address the barriers, policy packages have been developed for a shift towards a more healthy diet and for a shift towards a diet with a reduced animal protein intake. The former could be based on much more empirical evidence with regards to the effectiveness of policy instruments. A policy package comprising of taxes, school-based intervention and health labelling could reduce the gap between the current diet and a healthy diet by 22% in 2020, increasing to 28% in 2050, resulting in a decrease of life cycle emissions of circa 44 Mt CO_2e in 2020, increasing to 56 Mt CO_2e in 2050. Of these emissions, about one sixth is emitted from outside the EU. The impact of a policy package aimed at reducing animal protein consumption is much smaller, although this could be an underestimation because of lack of empirical data. While labelling is clearly within the scope of EU policy, school based interventions could potentially be introduced at a national level. Tax incentives would require unanimity amongst Member States to be implemented at an EU level.

1 Introduction

1.1 Policy context

The EU's overarching climate policy goal is to keep the global temperature increase below 2°C compared to pre-industrial levels. The Low Carbon Economy Roadmap (COM(2011) 112 final) shows that a transition towards a competitive low carbon economy means that the EU should prepare for reductions in its domestic emissions by 80% by 2050 compared to 1990. The Transport White Paper (COM(2011) 144 final) sets out how the transport system can reduce its emissions by 60% in the same period. In the shorter term, as complement to the EU Emissions Trading System (ETS) and its decreasing emission cap, the Effort Sharing Decision requires EU Member States to reduce non-ETS emissions by 10% in 2020 relative to 2005.

The current models for quantitative assessments of climate policies are implicitly or explicitly focused on technical mitigation measures and on behavioural changes induced by price based instruments. From these models, it is clear that there is a considerable potential to reduce emissions, both in the sectors covered by the EU Emission Trading System and in the non-ETS sectors. However, they also show that reaching ambitious targets in some non-ETS sector by conventional means may become quite costly.

An emerging body of literature shows that changes in consumption patterns can achieve considerable reductions in emissions at relatively low costs. This body of literature focuses on the emission reduction potential of behavioural changes, associated costs, and barriers to these changes and policy instruments to overcome these barriers. Many of these studies are case studies or qualitative assessments, and hence the results are not yet translated into scenarios or policy assessment models.

The Low Carbon Economy Roadmap and the Transport White Paper both also acknowledge that behavioural changes may be needed to reach the emissions targets or that the targets may be reached at lower costs of behavioural change would occur (see also the accompanying Impact Assessments SEC(2011) 288 final and SEC(2011) 358 final).

Because of the importance of behavioural changes, this study assesses their impacts on GHG emissions, focusing on domains not covered by the emission reduction incentives of the EU ETS. It also analyses which barriers exist to behavioural changes, whether policies can help overcoming these barriers and if so, to which extent.

1.2 Objectives

This study aims to contribute both to policy development and to policy evaluation. For the first aim, it analyses how policies can be used to overcome barriers to behavioural change. For the second, it analyses how models currently used in Impact Assessments can be amended to include behavioural change options and related policies.

Specifically, the study has three objectives:
1. To assess and demonstrate the GHG emission reduction potential of changes in behaviour and consumption patterns.
2. To analyse policy options for the further development of community policies and measures inducing changes in behaviour and consumption patterns. And
3. To identify the linkages with other technical and economic variables in such a way that it can be used in modelling and scenario development.

1.3 Scope of the study and selection of relevant behavioural domains

Many aspects of behaviour have an impact on GHG emissions. This study is mainly concerned with behaviour of households and consumers. The scope of the study includes non-ETS emissions only. This is particularly relevant for behavioural choices regarding electricity use, which are excluded from the analysis of this report.

Many of the mitigation options have an impact on emissions outside the EU. GHG are emitted in petroleum extraction and in growing fodder crops, for example. These emissions are not allocated to the EU in the UNFCCC reporting mechanism. However, they are clearly related to consumption in the EU. hence, this report takes them into account. In the food domain, where they are most significant, we report both total emissions associated with consumption and an estimate of EU emissions.

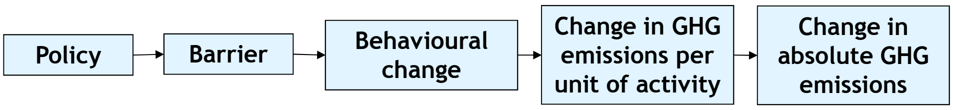
A large number of studies have assessed the relative contributions of consumer behaviour to environmental sustainability and GHG emissions. For example:
- Nemry et al. (2002) find that the most important categories of behaviour are 'passenger transport' (33% of total impact of products), 'interior climate' (31%), 'building structure' (11%).
- Labouze et al. (2003) find that the most important categories of behaviour are 'personal cars' (17%), 'space heating – domestic' (16%), 'building occupancy – commercial' (12%), 'transport of goods (road, rail, water)' (10%), 'domestic appliances' (8%).
- Nijdam and Wilting (2003) find that the most important categories of behaviour are 'non-animal based food' (12%), 'animal based food' (10%), 'heating' (9%), 'mobility for leisure' (8%), 'commuting, private transport' (8%).
- Moll et al. (2004) find that the most important categories of behaviour are 'electricity, gas, steam and hot water supply' (16%),'food products and beverages' (9%), 'motor vehicles, trailers and semi-trailers' (8%), 'construction' (7%).
- Weidema et al. (2005) find that the most important categories of behaviour are 'dwellings and heating' (7.7%), 'car purchase and driving', (6.0%), 'meat purchase' (3.4%), 'tourist expenditures' (3.7%).
- Tukker et al. (2006) find 'food and drink' (29%), 'transport' (18%), 'household equipment and maintenance' (16%), 'restaurants and hotels' (9%).

Taken in combination, the results of the studies reviewed are strikingly robust when it comes to climate impacts. In the studies that included them systematically, food and drink, mobility and housing are consistently the most important areas. Some studies also find high emissions in the domains of tourism and waste. It is worth to note however that in the tourism category, the major share of the climate impact is related to transport (especially air transport, see e.g. Gössling et al. 2010) while the problem of waste is at least to some extent covered in the food category and is already quite well tackled by policies. Therefore, in our report we decided to focus on the three main areas as identified in Tukker et al. (2006), namely on **'Food and drink', 'Housing' and 'Mobility'**.

1.4 Framework for analysis

The aim of the project is to assess the GHG emission reduction potential of changes in behaviour and consumption patterns, to analyse policy options that induce changes in behaviour and consumption patterns and to identify the linkages with other technical and economic variables in such a way that it can be used in modelling and scenario development. The basic framework for analysis is presented in Figure 1: behavioural changes can result in changes in GHG emissions per unit of activity. Depending on the activity level, they may also translate in changes in absolute emissions. While behaviour changes constantly, the change options considered in this report may not occur spontaneously. Often, incentives are needed to induce behavioural change, which may be provided by policies.

Figure 1 Framework for analysis

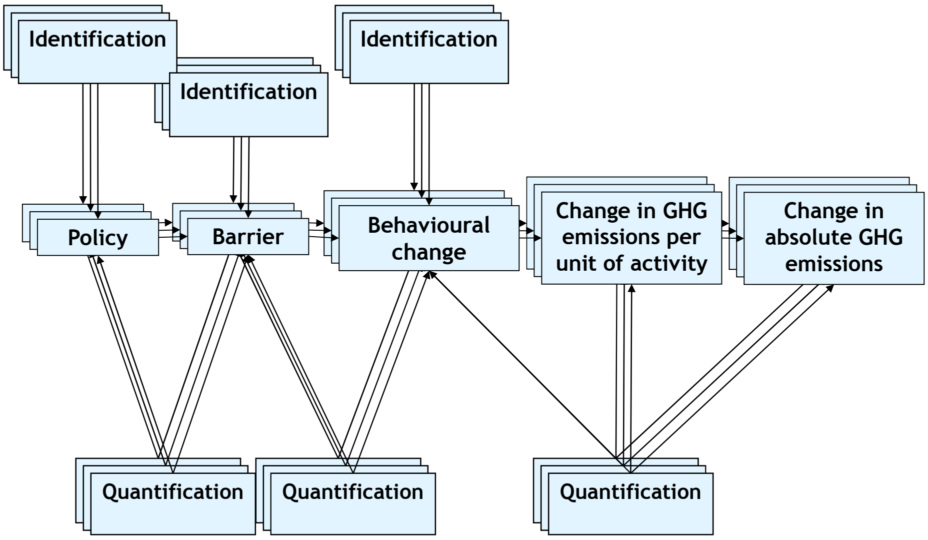


For each of the three selected domains (mobility, housing and food and drink), this project identifies behavioural change options reported in the relevant literature. For each option, it broadly assesses the mitigation potential.

In each domain, three to four behavioural change options are selected for further analysis. For these options, the mitigation potential is quantified and the barriers for these options and policies addressing these barriers through a literature review.

After a second selection, the study constructs effective policy packages for a selected set of behavioural change options, quantifies their impacts on behavioural change and provides a quantitative estimate of the impact of behavioural changes on GHG emissions. This is presented in Figure 2.

Figure 2 Overview of steps



1.5 Key concepts, definitions and data sources

1.5.1 Maximum realistic mitigation potential

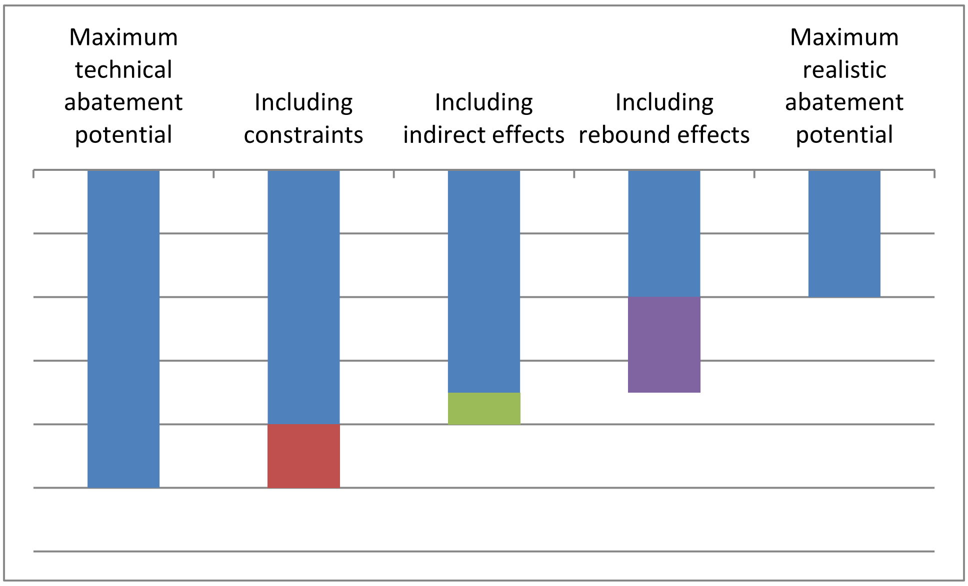
The impact of behavioural changes on GHG emissions is reported in terms of the *maximum realistic mitigation potential*. The maximum realistic mitigation potential is defined as the reduction in GHG emissions achieved when the option is adopted by the largest number of actors possible, taking into account realistic and structural constraints, indirect effects and rebound effects. Diffusion patterns are considered to be behavioural and are not taken into account in the calculation of the maximum realistic mitigation potential.

The assessment of the maximum realistic mitigation potential is carried out in six consecutive steps:

1. Gather the data on the option from the literature.
2. Review the literature based on expertise in the consortium and establish GHG reduction potential of the option, relative to the BAU projection, in 2020, 2030 and 2050.
3. Identify and quantify structural and technical constraints that limit the number of actors by which the option can be adopted.
4. Identify and quantify indirect effects on GHG emissions.
5. Identify and quantify possible rebound effects.
6. Transpose the GHG emission reduction to the EU, taking into account the constraints and to the extent possible indirect and rebound effects.

A graphical presentation of the method is given in Figure 3.

Figure 3 **Method to assess mitigation potential**



The BAU emissions and other relevant parameters of the BAU scenario for 2020, 2030 and 2050 have been taken from the PRIMES-GAINS EU-27 reference scenario 2010 as e.g. described in European Commission (2011e): Roadmap for moving to a competitive low carbon economy in 2050, Impact Assessment, SEC(2011)288.

1.5.2 Categories of behaviour

From an environmental-psychological point of view, two categories of behaviour are relevant in this study: habitual actions and intended behaviour. Habitual action comprises frequently repeated actions that are not the result of a planning process and are often only consciously controlled the first times they are carried out. After people have internalised these actions, they are steered by habits and routines (“do without thinking”, Barr, 2005, p. 1426). Examples of habitual action are heating and ventilation behaviour, driving styles, diets, et cetera. This type of behaviour is referred to in the literature also as “curtailment behaviour” (Abrahamse et al., 2005; Black et al., 1985; Gardner and Stern, 2002), “habitual action” (Barr, 2005), “direct energy saving choices” (Stern, 2002) or ”practices“ (Curtis et al., 1984). Importantly, changing habitual action does not require significant investments such as structural changes of a building’s interior or exterior or the purchase of cars or equipment. Instead, daily routines and living habits, or what we may call lifestyles, have to be altered. People may perceive this as a reduction of comfort, which introduces social barriers that need to be overcome.

Intended behaviour, on the other hand, comprises conscious behaviour involving planning and decision making. Examples of intended behaviour are technology choices. Technology choices involve behavioural decisions related to the purchase of technologies and appliances. Typical measures include purchases of cars, insulation of roofs or facades, purchase of energy efficient electric appliances, installation of solar thermal heating systems or the replacement of old windows. It is evident that for this kind of actions, conscious and deliberate reflexions act as prerequisite. Those decisions can often take a rather long time and are perceived as complex. This type of behaviour is also referred to as “efficiency behaviour” (Abrahamse et al. 2005; Gardner and Stern, 2002), “consumption oriented behaviour” (Barr et al., 2005), “technology choices” (Stern, 1992), “conserving actions”

(Dillman et al., 1983), “purchase related behaviour” (Van Raaij and Verhallen, 1983), or “energy efficiency choices” (Black et al., 1985). Influencing technology choices may require substantial investments and in the residential sector often even structurally engineered alterations of the building.

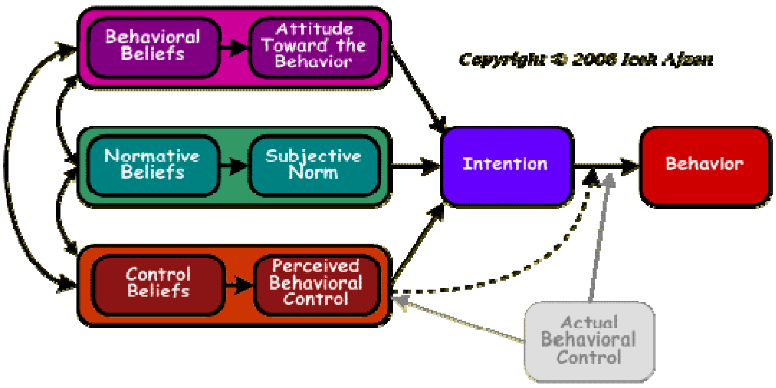
A distinction of the above mentioned behavioural categories is crucial for further research, given that customised practices and routines on the one hand, and one-shot actions in terms of strategic investment decisions on the other, must obviously be determined by different psychological, socio-demographical and structural factors (Frey et al., 1987). The focus of this study is on curtailment behaviour.

1.5.3 Behavioural change

Behaviour and behavioural change is often analysed using the Theory of Planned Behaviour (TPB) by Ajzen (1991; 2006), or its expansions. This theoretic framework is an efficient tool to identify crucial cognitions that underlie people's behaviour. In a nutshell, the theory states that a behavioural intention can lead to a manifestation of a specific behavioural reaction, while the intention itself is influenced by personal attitudes and beliefs toward the behaviour in question (see Figure 4). These attitudes reflect the degree to which performance of the behaviour is positively or negatively valued. Specifically, the evaluation of each outcome contributes to the attitude in direct proportion to the person’s subjective probability that the behaviour produces the outcome in question. A barrier occurs if the subjective probability that the behaviour will produce a given outcome is low. The model also incorporates normative beliefs, which are products of perceived social pressure towards the execution of the behaviour.

According to TPB, even when a strong intention exists to execute a behaviour, if factors are perceived that may impede performance, perceived behavioural control may prevent the behaviour from taking place. This phenomenon is usually referred to as the value-action gap, or attitude-behavioural gap: Even though studies often find that residents place a high value on environmental issues, their behaviour regarding daily energy use is very inefficient, or they do not purchase environmentally friendly products and services. One reason for this gap is that environmental awareness is just one attitude influencing behaviour, and that others such as comfort-seeking and price awareness may play a stronger role.

Figure 4 Theory of planned behaviour ‘TPB’



Source: Ajzen, 2006.

As its name suggest, the theory of planned behaviour does not directly explain habitual actions, the first category of behaviour described in Section 1.5.2. However, a change from a certain habit into another habit often requires at least a period of planned behaviour. Hence, the theory can be used to analyse barriers both for habitual action and for technology choices.

1.5.4 Barriers of behavioural changes

Barriers to behavioural changes can be understood in terms of the theory of planned behaviour, as factors that prevent an intention from being developed or as factors that prevent an intention turning into a behaviour. At the same time, a large body of literature exists that deals with barriers to behavioural change. An often used distinction is that between individual barriers and societal barriers. Based on a review of the literature, we come to the following categorisation (see Table 2):

- Individual (internal) barriers
  Although many consumer decisions are not made in a rationalised way, analysing underlying motives for certain choices helps to find barriers for behavioural change. Consumers make trade offs between advantages and disadvantages of certain lifestyles and product choices. These advantages and disadvantages may be related to costs, comfort, health, convenience, safety, quality, etc. The trade-offs made result from various factors which could act as (individual) barriers for behavioural change:
  - Social and psychological barriers: attitude, interest, beliefs, feelings and self efficacy/confidence.
  - Knowledge-based barriers: limitations in knowledge of the subject, or the ease with which it can be found.
  - Unconscious behaviour: routines and habits.
  - Demographic factors: age, education, gender, income.

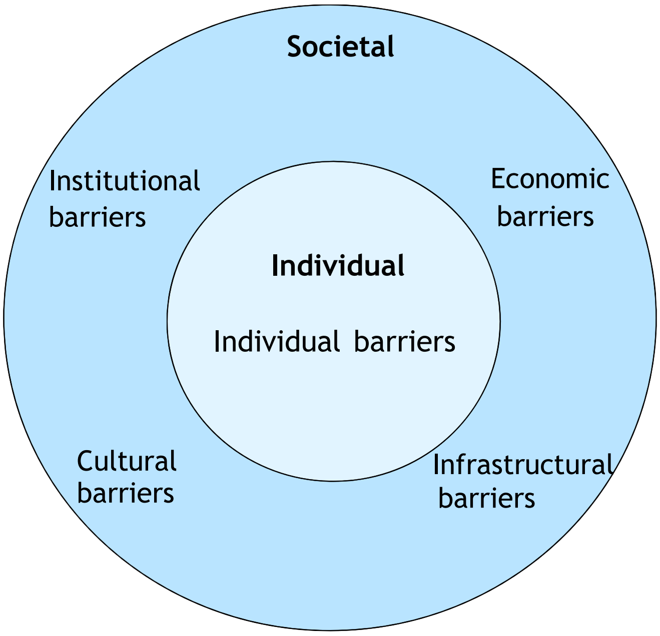
- Societal (external) barriers
  - Infrastructural barriers: lack of necessary infrastructure, e.g. people are less motivated to take the bike if no good structure of cycling lanes exists.
  - Cultural barriers: social norms and traditions, e.g. the custom to eat meat every day.
  - Economic barriers: people's ability to invest in environmentally friendly technologies may be limited by financial constraints.
  - Institutional barriers: law, politics and organisational structures. For example, the organisational structure of a firm may be a barrier for working at home.

Table 2 **Overview of barriers to behavioural changes**

Barrier category	Examples	Factor in Theory of Planned Behaviour
Individual (internal) barriers		
Social and psychological barriers	– No environmental concern – Political attitudes – No interest in energy-related topics – Emotions (e.g. health-related)	Attitude toward behavioural change
	– Risk-assessment: no threat perceived	Attitude, subjective norm
	– Attribution of responsibility to others – Low behavioural control	Perceived behavioural control
Knowledge-based barriers	– Lack of adequate information – Overestimation of own energy savings compared to others	Attitude toward behavioural change
	– Limited knowledge of consumers on their own space heating costs – Believe that no significant savings will occur	Perceived behavioural control
Unconscious behaviour	– Strong habits and routines (e.g. no habit to turn down heating)	No planned behaviour
Demographic factors	– Low income – Younger age – Gender differences	Attitude toward behavioural change Subjective norm Perceived behavioural control
Societal (external) barriers		
Structural and physical barriers	– No possibility to adjust room temperature, install thermostat, open the windows	Perceived behavioural control
Cultural barriers	– Comfort is a priority – No social norms towards energy saving – No social 'competition' or comparison – Social image not related to energy saving	Subjective norm
Economic barriers	– Decreasing energy prices	Attitude toward behavioural change Perceived behavioural control
Institutional barriers	– Lack of direct consumption feedback – Lack of incentives – Heating costs included in monthly rent – Political barriers	Perceived behavioural control

Most of the barriers identified above can be understood in terms of the theory of planned behaviour, either as factors related to the development of an intention or as a factor related to turning an intention into action (see Figure 5).

Figure 5 Different categories of barriers, divided between individual and societal barriers



1.5.5 Methodology for the quantification of the impacts of policies

The impacts of policies on behaviour and GHG emissions are quantified using published data including:

– *(ex-ante) evaluation studies* on the behavioural effects of the specific instrument (packages) implemented on a European scale, a national or local scale;
– *elasticity estimates*, especially for economic instruments;
– *known effects (e.g. from evaluation studies) of the implementation of the instrument(s) in contiguous (behavioural) areas*;
– *in the absence of other sources, in some cases expert judgement was used*.

In case of a combination of instruments the relation between the instruments and the impact of this relationship on the effects of the instruments has been considered.

1.6 Outline

The next chapters discuss, per domain, the behavioural change options identified in the literature, a quantitative assessment of the maximum realistic mitigation potential of selected options, barriers to these options, policy instruments with the potential to address these options and, for a selection of options, quantitative effects of policy packages on GHG emissions and government expenditures. Chapter 2 presents the study results for the Transport domain, Chapter 3 for Housing and Chapter 4 for the Food domain. Note that a more in-depth presentation of the results is provided in separate final reports for each of these domains. Chapter 5 concludes.

2 Mobility

2.1 Overview of behavioural changes

Four general classes of behavioural mitigation options in transport can be distinguished:

- Using more fuel efficient cars; people could reduce the climate impact of their mobility behaviour by using more fuel-efficient cars. E.g. they could choose for a smaller car or an electric car. Note that this study has excluded changes in purchase behaviour which do not significantly affect the way the product could be used. Therefore, behavioural changes like buying a more fuel efficient car (e.g. due to a more efficient engine) from the same size or buying cars running on alternative fuels (e.g. biofuels, natural gas) are not taken into account.
- Making use of the car in a more efficient way; by using passenger cars in a more efficient way GHG emission reductions of road transport could be realised. Efficiency measures that could be applied are: applying a more fuel efficient driving style, car pooling, sharing cars, etc.
- Using more sustainable modes; a shift to travel modes with relatively low GHG emissions per passenger kilometres (e.g. walking, cycling, public transport) could contribute to decarbonisation of transport. Other behavioural measures would be to participate in car-sharing projects or make use of collective transport programs organised by employers for commuting trips.
- Reducing travel distance; people could reduce the number of kilometres they travel in lots of ways: working at home, living near to the job, less holidays (to far-away countries), combining various trips, etc.

In the literature review, measures from all four classes are identified (see Table 3). However, not all possible behavioural measures are assessed in the literature. Especially behavioural mitigation measures related to less transport demand are poorly studied: no studies on living near to the job, less holiday travels, combining various trips, etc. are found.

It should be mentioned that behavioural mitigation measures with regard to air travel are not included, since aviation will be included in the European ETS system in 2012. Additionally, mitigation measures associated to freight transport are not taken into account, since the relation between consumer choices and climate impacts of freight transport is indirect and will be covered by the discussion of behavioural mitigation measures in other domains, e.g. Food and drink.

Table 3 **Behavioural mobility measures**

Behavioural change category	Behavioural change option
Using more fuel efficient cars	Buying and using smaller cars
	Buying and using electric or plug-in hybrids
Making use of the car in a more efficient way	Applying a fuel efficient driving style
	Increasing the occupancy rate of the car (incl. car pooling)
	Sharing a car
	Extending the life time of the car
Using more sustainable modes of transport	Travel by train instead of by car
	Travel by local public transport instead of by car
	Travel by bicycle instead of by car
	Travel by foot instead of by car
Reducing travel distance	Teleworking
	Apply visual meetings
	Make (more) use of e-commerce

2.2 GHG abatement potential of selected behavioural changes

From the list of options reported in Section 2.1, four change options were selected for further analysis. The selection was based on data availability, mitigation potential and policy relevance. The selected change options are:

1. Buying and using an electric car or plug-in hybrid.
2. Buying and using a smaller car.
3. Applying a fuel-efficient driving style.
4. Making use of ICT to decrease business travel: teleworking and applying virtual meetings.

The maximum realistic mitigation potential of the four car based behavioural change options are presented in Table 4. Buying and using electric cars has the highest mitigation potential (particularly on the long term), mainly because of the large maximum technical potential and the lack of non-behavioural constraints on the longer term. However, it should be mentioned that the mitigation potential of this behavioural change is probably an overestimation, since the impact of large-scale shift to electric vehicles on the power supply sector (a possible shift to electricity generated by fossil fuels) is not taken into account. The mitigation potential for the use of plug-in hybrids is smaller than for electric vehicles because they use fossil fuel. Buying and using smaller cars and applying a fuel efficient driving style have a smaller maximum realistic mitigation potential, amongst others because they lower the cost of driving significantly and therefore have a rebound effect. The potential of applying a fuel efficient driving style is projected to decrease over time due to the deployment of advanced vehicle technologies, which automate eco-driving techniques.

Table 4 **Maximum realistic CO_2 mitigation potential of car based behavioural change options**

Behavioural change	2020	2030	2050
Buying and using an electric car: per pkm	19-34%	64-72%	82-90%
Buying and using an electric car: Absolute CO_2 mitigation potential (Mton)	96-174	330-371	420-462
Buying and using an plug-in hybrid: per pkm	11-22%	39-56%	49-69%
Buying and using an plug-in hybrid: Absolute CO_2 mitigation potential (Mton)	56-113	198-286	251-354
Buying and using a smaller car: per pkm	17-20%	18-21%	18-21%
Buying and using a smaller car: Absolute CO_2 mitigation potential (Mton)	80-96	74-88	71-84
Fuel efficient driving style: per pkm	10%	7%	2%
Fuel efficient driving style: Absolute CO_2 mitigation potential (Mton)	47	32	10

Table 5 shows the maximum realistic CO_2 mitigation potential of teleworking and virtual meetings. The maximum realistic mitigation potential of teleworking is equal to ca. 5 to 8% of the total CO_2 emissions of passenger transport in the EU-27. The maximum realistic mitigation potential of virtual meetings equals 6 to 9%. It should be noted that the uncertainty in these estimations are quite large, especially since not all rebound effects could be quantified. Moreover, in case the rebound effects were quantified, the uncertainties in these quantifications are rather large.

Table 5 **Maximum realistic CO_2 mitigation potential of teleworking and virtual meetings**

Behavioural change	2020	2030	2050
Teleworking: Relative reduction in CO_2 emissions of total passenger transport	5-6%	6-7%	6-8%
Teleworking: Absolute CO_2 mitigation potential (Mton)	35-45	38-47	40-49
Virtual meetings: Relative reduction in CO_2 emissions of total passenger transport	6%	6%	9%
Virtual meetings: Absolute CO_2 mitigation potential (Mton)	39	35	55

Figure 6 and Figure 7 show, by way of example, how the maximum realistic mitigation potentials has been calculated for two behavioural change options, viz. buying and using electric cars and teleworking.

The composition of the maximum realistic CO_2 reduction potential of buying and using electric cars for 2020 is shown in Figure 6. The main part of the maximum reduction potential could be allocated to the direct CO_2 effects of buying and using electric cars. This effect results in 59% lower CO_2 emissions.

The indirect CO_2 effects (CO_2 emission reduction related to fuel production and vehicle production) contribute another 6% to the reduction potential. Some of this reduction potential may be outside the EU. Due to a lack of information it was not possible to estimate the impact of potential rebound effects.

The theoretical maximum potential of teleworking is equal to 15% of the total CO_2 emissions of passenger transport. This includes lower transport emissions, lower emissions associated with heating offices and higher emissions associated with heating homes. However, since about half of the jobs in the EU need to be executed in a certain place (a factory, shop, etc.) and since employees that need not be in a specific location still need to meet colleagues and/or clients, the theoretical maximum potential is reduced by 60%. The reduction potential is slightly extended by the indirect CO_2 effects (less CO_2 emissions due to lower fuel production), ca. 1%. Of the resulting reduction potential about 20% is undone by people using their car for other purpose instead of commuting. So the final maximum CO_2 mitigation potential in 2020 is estimated at 5 to 6%. Notice, that this potential is probably an over-estimation, since we were not able to quantify all rebound effects. A more detailed discussion and references to studies on which this assessment is based can be found in the Transport domain report.

Figure 6 **Composition of the maximum realistic mitigation potential of buying and using electric cars in 2020**

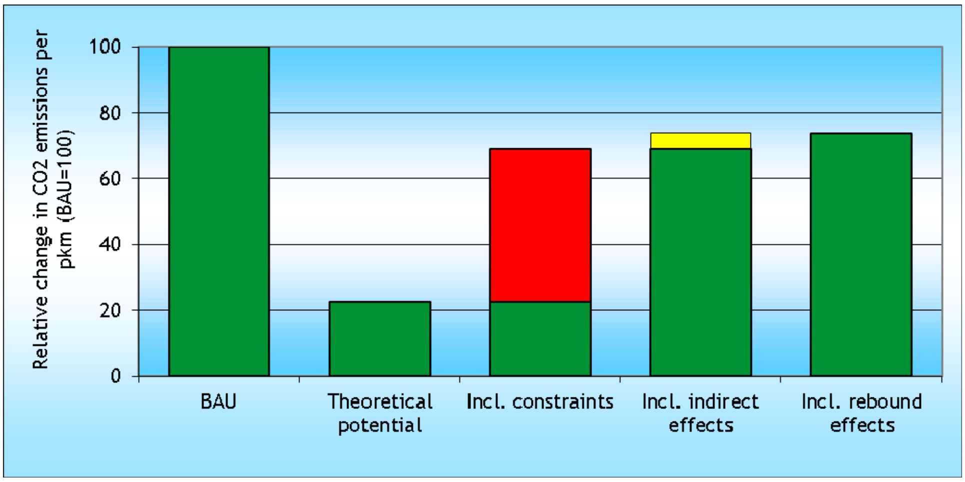
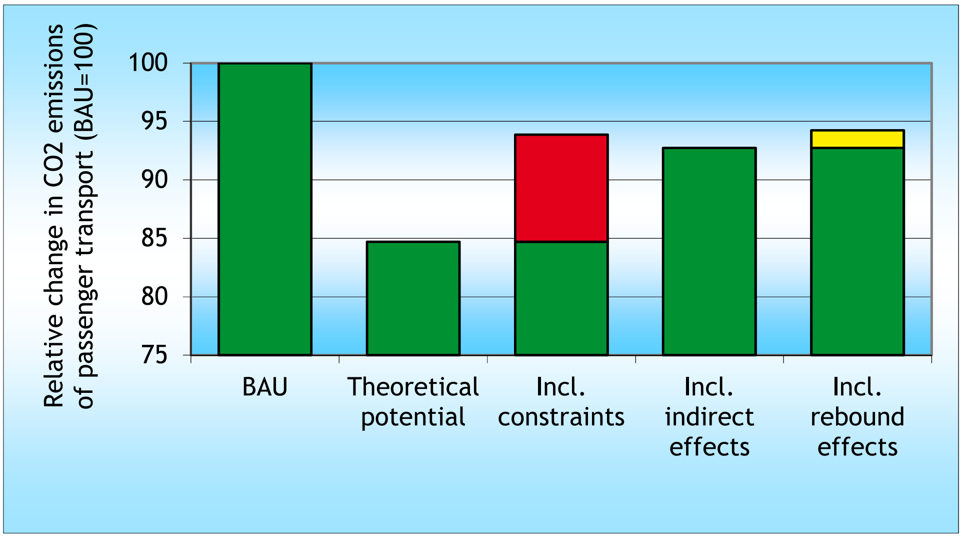


Figure 7 Composition of the maximum realistic mitigation potential of teleworking in 2020



2.3 Barriers and policies related to electric cars and plug in hybrids

Table 6 presents an overview of the barriers related to buying an electric car or a plug-in hybrid. The main barriers are at both the individual as societal level.

At the individual level consumers rather negative attitude to electric and plug-in hybrid cars are a main barrier. Electric cars are perceived as less attractive than conventional cars on many dimensions: performances (e.g. range), reliability, costs, image, etc. Additionally, electric and plug-in hybrid vehicles may challenge mobility-related habits of people, forcing people to change their lifestyles. For example, due to the long recharging time the use of electric cars is perceived to be less flexible than the use of conventional cars.

At the societal level structural barriers (the poor availability of charging infrastructure and the limited number of electric and hybrid vehicle models) and economic barriers (high purchase costs) are the main barriers for an uptake of electric and plug-in hybrid vehicles.

Table 6 **Overview of barriers for buying and using an electric car or plug-in hybrid**

Barrier category	Examples
Individual (internal) barriers	
Social and psychological barriers	– Rather negative attitude of consumers to electric cars due to: worse performances compared to conventional cars, doubts on reliability, safety issues, rather high costs, soft image – Electric cars challenge the mobility-related habits of people
Knowledge-based barriers	– Knowledge of consumers of electric and plug-in hybrid cars is rather poor
Societal (external) barriers	
Structural and physical barriers	– Insufficient network of charging infrastructure – Limited availability of electric/plug-in hybrid cars – Not enough second-hand cars
Cultural barriers	– Uncommon in peer group
Economic barriers	– High initial investment costs – Uncertainties about the long-term value of the car – Perceived high maintenance costs
Institutional barriers	– Perceived reluctance of automobile dealers (and manufacturers) to actually sell electric and plug-in hybrid cars – Lack of government support

Table 7 presents an overview of policy instruments that can in principle be used to overcome the barriers to the purchase and use of electric and plug-in hybrid cars. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the transport domain report.

Table 7 **Overview of policy instruments which can be used to stimulate the purchase of electric and plug-in hybrid cars**

Policy category	Examples
Regulative instruments	– Quota for (relative) number of electric/plug-in hybrid cars to be sold by manufacturers – Urban access restriction schemes focused on electric and plug-in hybrid cars – Use of parking policies to stimulate the purchase of electric and plug-in hybrid cars – Developing common plug and charging standards – Prescription of smart charging infrastructure – Require investments in charging infrastructure – Beneficial treatment of electric and plug-in hybrid cars with regard to vehicle emissions standards
Economic instruments	– Differentiated vehicle taxes – Energy taxes – Differentiated road charges – Subsidies on purchases of electric vehicles or the installation of charging points – Subsidies for the development of electric vehicles (e.g. battery technology)
Communication	– Information campaigns – CO_2/energy labelling – Providing comparisons of electric and plug-in hybrid cars with conventional cars – Demonstration projects
Direct governmental expenditures	– Public investments in charging infrastructure – Green procurement: investing in electric or plug-in hybrid vehicles
Procedural instruments	– Voluntary agreements with organisations to use electric or plug-in hybrid cars

While it is clear that behavioural changes are held back by several barriers, and hence a mix of policy instruments may be needed to effectively induce the behavioural change, not all policy instruments listed in Table 6 can be combined. Some of the main interaction effects are:

- Various instruments meant to stimulate the investments in charging infrastructure are discussed (e.g. subsidies, regulations, governmental investments). Applying these instruments at the same time may lead to an overlap and hence negative interaction effects. However, given the enormous investments needed CE et al. (2011) recommend to use a mix of these instruments.
- Regulative instruments, like electric vehicle friendly parking policies, and economic instruments like fuel taxes may reinforce each other, since they provide consumers both a comparable incentive. However, if the regulative instruments are applied on a large scale (not only in some city centres, but in whole regions or even countries), these instruments may largely overlap; in that case they would negatively affect each other.

- Economic instruments like differentiated vehicle taxes, fuel taxes and road charges may reinforce each other, but they could also overlap each other. If a combination of these instruments provides a financial incentive sufficiently large to change the consumer's behaviour, these instruments reinforce each other. However, if the needed financial incentive could also be realised by just one of these instruments the implementation of the other instruments is redundant and result in distortions. Therefore combining these measures in a policy package should be carefully considered.
- The various instruments related to communication will probably reinforce some of the other policy instruments. People with more knowledge on electric cars are probably more willing to buy one if fuel taxes increase or city centres are only available with electric cars.
- Investing in electric or plug-in hybrid cars for governmental agencies may, if visible to people, serve as a good example and may stimulate consumers to buy these kinds of cars themselves.

2.4 Barriers and policies related to small cars

An overview of the barriers related to the purchase of smaller cars is shown in Table 8. Most of the main barriers are individual ones, indicating that consumers are often able to buy a smaller car, but that they are not always willing to do so.

Table 8 Overview of barriers for buying a smaller car

Barrier category	Examples
Individual (internal) barriers	
Social and psychological barriers	– Consumers prefer a large car over a small one, since large cars are more practical and safer. Additionally, for some consumers large cars have preferable symbolic/ affective advantages (e.g. better image) – Fuel consumption/environmental performances are no top priority of car buyers – Small cars may challenge the mobility-related habits of people
Knowledge-based barriers	– Limited knowledge of consumers on their own fuel costs
Structural and physical barriers	– Limited number of small car models available on the market
Cultural barriers	– Pressure from peers to buy a large car
Institutional barriers	– Reluctance of car dealers to sell smaller cars

Several demographic factors may influence the resistance of people to buy a smaller car:
- *Household size;* one- or two-person households will be more likely to buy a small car than households with children (Choo and Mokhtarian, 2004; Kitamura et al., 2000), since for the latter the internal space of the car will be more of a key factor in the car purchase decision.
- *Gender;* women are expected to be more likely to buy a small car than men (Choo and Moktharian, 2004). Women are less concerned to the status of car and, in addition, are more concerned on the environmental performance of the car (Johansson-Stenman and Martinsson, 2006).

– *Educational level;* it may be expected that higher educated people are more likely to convince smaller cars (Choo and Mokhtarian, 2004). According to Johansson-Stenman and Martinsson (2006) these people are less concerned on the status of their car. Additionally, environmental concern is often expected to be higher for high-educated people than for low-educated people.
– *Place of residence;* people living in the city are more willing to buy a smaller car than people living on the countryside. Since the latter group will use the car more often, they prefer a more comfortable car than citizens. Additionally, small cars are more practical in the dense urban traffic.

As we saw before, the main barrier to buying smaller cars is consumers' attitude to these types of cars. To change this attitude will take some time. For example, it will take some time to convince people that they don't need to change their lifestyle if they buy a smaller car. Also the symbolic values related to small and large cars need time to change. Therefore, it will require long-term policy instruments to stimulate the purchase of smaller cars on a large scale.

Table 9 shows a list of policy instruments that can be used to overcome barriers to the purchase and use of smaller cars. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the transport domain report.

Table 9 Overview of policy instruments to stimulate the purchase of smaller cars

Policy category	Examples
Regulative instruments	– Regulate maximal size/weight of cars
Economic instruments	– Differentiated purchase taxes – Fuel taxes or inclusion in EU ETS – Differentiated registration taxes – Differentiated road charges
Communication	– CO_2/energy labels for passenger cars – Providing information via independent websites or guides – Providing information via sales persons – Mass communication
Direct governmental expenditures	– Green procurement: only buying small cars
Procedural instruments	– Voluntary agreements with companies to buy small company cars

If the various policies are implemented in policy packages some interaction effects affecting the effectiveness of the individual instruments may occur. Some of the main interaction effects are:
– As for electric and plug-in hybrid cars, the various economic instruments (differentiated vehicle taxes, fuel taxes, road charges) may both reinforce and overlap each other, depending on the design of these instruments (see also Section 2.3). Therefore, combining these instruments in a policy package should be carefully considered.

– The various instruments related to communication will probably reinforce some of the other policy instruments. People with more knowledge on the impact of fuel efficiency on total cost of ownership are probably more willing to buy a smaller car than people without this knowledge.
– Investing in smaller cars for governmental agencies may, if visible to people, serve as a good example and may stimulate consumers to buy these kinds of cars themselves.

Based on the analysis of barriers and policy instruments we also composed for further examination (in close agreement with the Commission) a policy package for stimulating the purchase and use of smaller cars. This policy package consists of the following five policies:
– a CO_2 differentiated purchase tax;
– a CO_2 differentiated company car tax;
– a (CO_2 differentiated) increase of fuel taxes;
– spatial policies favourable to smaller cars, like parking charges differentiated to the size of the car and restricted access to city centres for large cars;
– a supportive communication strategy, consisting of CO_2/energy labels and the provision of data via an independent website.

This policy package provides strong (financial and regulative) incentives for consumers to change their car purchase and use behaviour. In this way the main psychological barriers to buying smaller cars (see above) could be addressed.

A rough estimation of the effectiveness (in terms of CO_2 reductions) of the entire policy package[1] is presented in Table 10. Both the CO_2 impacts of the individual policy instruments as the CO_2 impact of the entire policy package is presented. We were not able to quantify the CO_2 impact of spatial policies favourable to small cars. These estimates do not take account of interaction effects with the existing EU CO_2 and cars regulation which currently sets emission limits for 2015 and 2020. These interactions could significantly reduce the effect of purchase or company car taxes on CO2 reductions.

Table 10 Rough estimation of the relative CO_2 reductions of passenger cars of both individual instruments and policy packages for stimulating the purchase and use of smaller cars

Policy (package)	CO_2 reduction due to smaller cars	Total CO_2 reduction
CO_2 differentiated purchase tax	3-4%	6-10%
CO_2 differentiated company car tax	2-3%	4-7%
10% fuel tax increase	0.5%	3-4%
20% fuel tax increase	1%	6-8%
Spatial policies favourable to small cars	?	?
Supportive communication strategy	Not significant	Not significant
Policy package 1 (incl. fuel tax increase of 10%)	At least 6-8%	At least 13-21%
Policy package 2 (incl. fuel tax increase of 20%)	At least 6-9%	At least 16-25%

Note: Due to possible interaction effects, the CO_2 impacts of individual policy instruments do not necessarily add up to the CO_2 impacts of the various policy packages.

[1] Two policy packages are distinguished, differing in the fuel tax increase assumed: 10 and 20% respectively.

Implementation of the proposed policy package could result in the longer term in 6-8% (or 6-9% in case a fuel tax increase of 20% instead of 10% is introduced) lower CO_2 emissions of passenger cars due to the purchase and use of smaller cars. By implementing a supportive communication strategy the actual CO_2 reduction could shift to the upper bound of the presented bandwidth, although the same caveats apply.

Many of the policy instruments applied in this policy package do have broader CO_2 impacts than only affecting the purchase and use of smaller impacts (e.g. a fuel tax provides also incentives to reduce the demand for transport). If these broader impacts are also taken into account, the reduction potential increases by a factor 2.5 (see the third column of Table 10).

It should be noted that these reductions depend to a large extent to tax incentives, which would require unanimity amongst Member States to be implemented at an EU level.

2.5 Barriers and policies related to a more fuel-efficient driving style

An overview of the identified barriers for applying a more fuel-efficient driving style is shown in Table 11. Most of the main barriers are individual (internal) barriers, indicating that people perceive that they should be able to apply a more fuel efficient driving style, but (that some of them) are not willing to do that or do not know how to do that.

Table 11 Overview of barriers for applying a more fuel efficient driving style

Barrier category	Examples
Individual (internal) barriers	
Social and psychological barriers	– Some drivers like to apply an aggressive (non fuel-efficient) driving style – Driving behaviour is habitual and therefore difficult to change
Knowledge-based barriers	– Gathering information on fuel-efficient driving is perceived difficult – Many drivers already think they drive well and do not realise the potential for improvement – Drivers do not know exactly how to apply the tips and tricks for fuel-efficient driving
Societal (external) barriers	
Structural and physical barriers	– The application of a fuel-efficient driving style may be hindered by traffic conditions – Some car types are more suitable to apply a fuel-efficient driving style
Cultural barriers	– Peer group pressure to apply an aggressive (non fuel-efficient driving style)

Table 12 presents an overview of possible policy instruments to overcome barriers to applying a more fuel-efficient driving style. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the Transport domain report.

Table 12 Overview of policy instruments to stimulate the application of a more fuel-efficient driving style

Policy category	Examples
Regulative instruments	– Obligation to include eco-driving in driving lessons – Obligation to equip vehicles with ICT that facilitates eco-driving techniques
Economic instruments	– Subsidising eco-driving courses – Subsidising tools which assist a fuel-efficient driving style – Fuel tax or inclusion of transport in ETS
Communication	– Mass campaigns – Targeted information campaigns (e.g. driving schools, fleet managers) – Training of driving instructors
Direct governmental expenditures	– Eco-driving programs at governmental agencies
Procedural instruments	– Voluntary agreements with companies to apply eco-driving programmes (e.g. leasing companies) – Voluntary agreement with car manufacturers or dealers to provide a voucher for a eco-driving course to buyers of a new car

If the various policies are implemented in policy packages some interaction effects affecting the effectiveness of the individual instruments may occur. The main interaction effects are:

- Following an eco-driving course (as specific measure, as part of the driving lessons, as part of an eco-driving program at governmental agencies or as part of a voluntary agreement) and increased fuel taxes (or inclusion of transport in ETS) will reinforce each other. The increase in fuel taxes provides car users an incentive to actually apply the fuel-efficient driving style learnt during the course.
- Providing information (via mass or targeted campaigns) to consumers on applying a more fuel-efficient driving style may have a positive interaction with the economic instruments. If people are aware of fuel-efficient driving, they are more willing to follow a subsidised eco-driving course. Additionally, awareness of fuel-efficient driving (tricks) increase the probability that people would apply such a driving style if fuel prices increase due to increased fuel taxes.
- Providing information may also be a good way to reinforce the driving style learnt during an eco-driving course. Therefore, positive interaction effects may exist between providing information and following an eco-driving course (also if included in the regular driving lessons).
- Eco-driving programs at government agencies may, if visible, stimulate car users to follow an eco-driving course themselves or apply the driving style learnt during an eco-driving course.
- The obligation to include eco-driving in regular driving lessons may on the long-term negatively affect the effectiveness of providing specific eco-driving courses to car users. The effectiveness of an eco-driving course will be lower if the fuel-efficient driving style has already been learnt in the past. However, the eco-driving course may also act as a 'reminder' and hence reinforce the effectiveness of the inclusion of eco-driving in the regular driving lessons.

2.6 Barriers and policies related to teleworking

In Table 13 an overview of the barriers to teleworking is given. The main barriers for teleworking are the social/psychological and institutional ones.

The social/psychological barriers refer to people's perceptions of the drawbacks of teleworking: social isolation, tendency for overworking, adverse impacts on career, mixing up private and professional life, etc.

The institutional barriers are related to the resistance of organisations and direct managers to allow their employees to work at home. Reasons for this resistance are concerns on the productivity of employees, security issues, adverse impacts on teambuilding, etc.

Table 13 Overview of barriers to teleworking

Barrier category	Examples
Individual (internal) barriers	
Social and psychological barriers	People may prefer to work not at home (permanently) due to: – Fear for social isolation – Tendency for overwork – Fear for adverse impacts on employees' careers – Stress due to more autonomy – Unwanted mixing of work and private life
Cultural barriers	– Social norm against teleworking
Institutional barriers	– Lack of support from organisation and direct manager

Table 14 presents an overview of possible policy instruments to overcome barriers to teleworking. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the Transport domain report.

Table 14 Overview of policy instruments to stimulate teleworking

Policy category	Examples
Regulative instruments	– Developing a regulatory framework concerning the employment conditions of teleworkers – Developing a regulatory framework enabling and stimulating investments in broadband IT infrastructure
Economic instruments	– Subsidies for necessary (ICT) equipment – Subsidies for home energy bills – Tax credits for companies reducing their employees' commuting kilometres due to teleworking – Innovation subsidies – Fuel taxes and road use charges
Communication	– Communicate best practices of teleworking to employees and employers – Communicate the direct link between GHG reduction and teleworking – Providing training assistance
Direct governmental expenditures	– Providing civil agents the possibility to work at home
Procedural instruments	– Voluntary agreements with companies to stimulate and facilitate teleworking

In a policy package aimed at stimulating teleworking, policies may interact, i.e. either be synergetic or counterproductive. Therefore we briefly discuss the main interaction effects between the various individual policy instruments:
– The various regulative instruments are just meant to provide an environment in which teleworking could be applied more easily. Therefore these instruments only provide positive interaction effects with other instruments. For example, higher fuel taxes will result in higher teleworking rates if there is a favourable regulatory framework on the employment conditions of teleworkers.
– Also the instruments related to communication reinforce most of the other instruments. Voluntary agreements would, for example, be more effective if employees of organisations taking part in these agreements are aware of the individual benefits associated with teleworking.
– As for some of the other behavioural changes, some of the economic instruments (affecting the same agents) may both reinforce and overlap each other. Therefore, combining these instruments (e.g. increasing fuel taxes and subsidies for home energy bills) in a policy package should be considered carefully.
– Providing civil agents the opportunity to work at home may, if visible to other workers, serve as a good example to other organisations and employees and hence may reinforce the various other instruments.

Finally, we composed for further investigation (in close cooperation with the Commission) the following policy package to stimulate teleworking:
– an increase of fuel taxes;
– development of a regulatory framework concerning employment conditions of teleworkers;
– support provision of (broadband) IT infrastructure and equipment;
– EU communication campaign;
– voluntary agreements with private organisations;
– stimulating teleworking at governmental institutions.

The policies in this package address both the psychological barriers related to employees' doubts on some aspects of teleworking, like social isolation and adverse impacts on one's career (e.g. by providing a set of clear employment conditions for teleworkers) and the institutional barriers related to the lack of support of managers/organisations (by arranging voluntary agreements and providing information on the advantages of teleworking for organisations).

The effectiveness of the policy package to stimulate teleworking could not be estimated in quantitative terms due to a lack of information on the impacts of the individual instruments in the literature. However, despite the fact that the policy package contains particularly soft instruments, we expect that it could be effective in stimulating teleworking. The main reason for this is that tele-working provides a lot of benefits for both employers and employees, and hence by removing some of the main barriers a significant shift to teleworking may be realised. Since some of the main barriers could be effectively over-come by the proposed soft measures (e.g. fear for adverse impacts on one's career by providing a clear set of employment conditions for teleworkers) the selected policy package could significantly affect the amount of teleworking. However, it should also be mentioned that some of the barriers, like fear for social isolation, will become very tough if teleworking is applied on a large scale (e.g. four days a week) and hence will probably not be tackled by the policies proposed.

2.7 Barriers and policies related to virtual meetings

Table 15 presents an overview of barriers to applying virtual meetings. The main barriers exist at both the individual as societal level.

At the individual level, people's perception that virtual meetings are a poor substitute for physical meetings is a main barrier. Especially for meetings meant to exchange non-tangible values like trust or interest, virtual meetings are often perceived as inappropriate.

At the societal level, the main barrier refers to the institutional context. Organisations/managers resistance to allow their employees applying virtual meeting is an important barrier for this behavioural change.

Table 15 Overview of barriers to applying virtual meetings

Barrier category	Examples
Individual (internal) barriers	
Social and psychological barriers	– Virtual meetings are in some cases perceived as poor substitutes for physical meetings – People prefer to meet people in real – Business trips are seen as advantages of a job
Knowledge-based barriers	– Lack of knowledge how to use sophisticated equipment – Lack of knowledge how to apply virtual meeting in an efficient way
Societal (external) barriers	
Structural and physical barriers	– Availability but especially quality of equipment is not always sufficient
Cultural barriers	– Cultural resistance to change current way of organising meetings
Economic barriers	– Relatively high cost for sophisticated videoconferencing equipment, especially for small and medium sized organisations
Institutional barriers	– Applying virtual meetings is not supported by the organisation and direct managers

Table 16 presents an overview of possible policy instruments to overcome barriers to virtual meetings. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the Transport domain report.

Table 16 Overview of policy instruments to stimulate the application of virtual meetings

Policy category	Examples
Regulative instruments	– Developing a regulatory framework enabling and stimulating investments in broadband IT infrastructure
Economic instruments	– Subsidies for virtual meeting equipment – Tax credits for companies reducing their employees' commuting kilometres due to teleworking – Innovation subsidies – Fuel taxes, road use charges, charges for rail and air transport
Communication	– Communicate best practices to employees and employers – Communicate the direct link between GHG reduction and teleworking – Providing training assistance
Direct governmental expenditures	– Providing civil agents the possibility to apply virtual meetings
Procedural instruments	– Voluntary agreements with companies to apply virtual meetings

If the various policies are implemented in policy packages some interaction effects affecting the effectiveness of the individual instruments may occur. The main interaction effects are:

- The stimulation of the improvement of ICT infrastructure (regulative instrument) is meant to provide an environment in which virtual meetings could be applied more easily. Therefore this instrument only provides positive interaction effects with other instruments.
- As for teleworking, the instruments related to communication reinforce most of the other instruments.
- As for teleworking, some of the economic instruments (affecting the same agents) may both reinforce and overlap each other. Therefore, combining these instruments in a policy package should be considered carefully.
- Providing civil agents the opportunity to apply virtual meetings may, if visible to other workers, serve as a good example to other organisations and employees and hence may reinforce the various other instruments.

2.8 Conclusion

Behavioural changes in passenger transport may lead to lower GHG emissions in the EU. Changing purchase and use behaviour of cars could maximally result in a reduction of 10-68% per passenger kilometre in 2020, increasing to 90% in 2050. This would equate a reduction of 47-349 Mt CO_2 in 2020, relative to the PRIMES/GAINS reference scenario projection, and up to 462 Mt in 2050. However, these figures assume that the maximum realistic abatement potential is reached, meaning, for example, that all consumers who in principle can use an electric vehicle will do so.

Reducing transport demand by increased teleworking and applying virtual meetings could maximally result in a reduction of 10-11% of GHG emissions associated with passenger transport in 2020, increasing to 15-17% in 2050. Relative to the PRIMES/GAINS reference projection, the reduction could be 74-84 Mt CO_2 in 2020 and 95-104 Mt in 2050.

Currently, several barriers inhibit these behavioural changes. Changes in car purchase and use behaviour are mainly held back by social and psychological barriers, such as preferences for conventional cars, challenges to mobility related lifestyles and the image of a car, although other types of barriers may also be relevant. In the case of electric vehicles, economic barriers are also important as these cars have high initial costs. Teleworking and virtual meetings are mainly held back by social/psychological (e.g. fear for social isolation and adverse impacts on careers) and institutional (lack of support from managers/organisations) barriers.

A wide variety of policy instruments could be implemented to address the barriers related to the mobility related behavioural changes. In this study we assessed the effectiveness of specific policy packages for two behavioural changes in transport: buying and using smaller cars and teleworking.

The policy package with regard to smaller cars consists of economic and regulative instruments supported by informational measures. The longer term abatement potential of this policy package was estimated at 6-9% of the CO_2 emissions per pkm (24-35 Mt in 2050), although the extent to which this potential can be realised also depends on interactions with the CO_2 and cars emission regulation. Full realisation would correspond to about 30 to 40% of the maximum realistic abatement potential.

The policy package with respect to teleworking consists of a wide variety of measures, including economic, regulative, informational and procedural instruments. We estimate that this policy package results in about 6-12% less commuting travel and hence 1% less CO_2 emissions of total passenger transport (7 Mt in 2020). This corresponds to about a sixth of the maximum realistic abatement potential. However, it should be mentioned that these figures are very rough estimates; since the empirical evidence on the effectiveness of policy instruments with respect to teleworking is very scarce, it was not possible to come up with a more reliable estimation. Therefore, the figures with respect to the effectiveness of policies stimulating teleworking should be considered carefully.

3 Housing

3.1 Overview of behavioural changes

It is widely acknowledged in the literature that user behaviour significantly influences energy use in the housing sector. However, the extent to which variations in energy use are due to variations in user behaviour is still largely unknown. Thus, also quantitative analyses of the potential of behavioural change measures can hardly be found in the literature.

In the residential sector energy is primarily used for space heating and cooling, water heating, lighting and electric appliances. If the focus of analyses is directed to non-electricity space and water heating are the main domains for achieving consumption patterns that are sustainable with regard to climate change. Cooling, e.g. using air-conditioning, is an additional domain, especially for the warmer parts of the EU, that is gaining importance also in relation of the hotter climate to be expected in consequence of climate change. Research has found that energy demand for space heating is positively related to the age of the occupants (older households consuming more energy), household size, income and ownership (more energy used in rented dwellings). Energy use for heating has been estimated to vary by the factor of two depending on variations in user behaviour.

From a theoretical point of view, behavioural measures in relation to energy use in households mainly comprise two categories: so called efficiency as well as curtailment behaviours. The first one include one-shot behaviours like the decision on and investment in equipment used, i.e. the energy source and the appliance for generating energy. Insofar as these behaviours do not require a continuing change in behaviour and are already more often covered by models, they are not considered in this study. The second category refers to repetitive and, once learned, usually habitual efforts to save energy by changes in everyday behaviour, i.e. the operation of appliances, preferred room temperatures, usage patterns with regard to opening windows, etc. Some of these behavioural measures imply a change of routines without changing lifestyle (e.g. optimised operation of heating installations without reducing the room temperature), others imply greater changes (e.g. reduced room temperature).

Table 17 shows the results of a literature research for behavioural change options in the housing sector and in non-residential buildings. More information on each of these options, including references and fact-sheets, can be found in the housing domain report.

Table 17 Overview of behavioural change options in the housing sector

Behavioural measure	Related factsheets
Housing	
Bundle of heating related behaviours including reducing room temperatures	Abrahamse et al., 2007
Combined effect of reducing room temperatures and ventilation rates	Öko-Institut, 2000
Reduced use of electric ventilation	BC Hydro, 2007
Reducing space heating temperature (lowering room temperature)	BC Hydro, 2007; Bohunovsky et al., 2010; Gardner and Stern, 2008; Guerra Santin et al., 2009
Reducing heated space	BC Hydro, 2007; Bohunovsky et al., 2010; Gardner and Stern, 2008; Guerra Santin et al., 2009
Reduced use of space heating	BC Hydro, 2007; Bohunovsky et al., 2010; Gardner and Stern, 2008; Guerra Santin et al., 2009
Optimising thermostat settings of heating, leaving room temperatures at the same level	Dietz et al. (2009); Gardner and Stern (2008)
Optimising water heater settings	Dietz et al. (2009); Gardner and Stern (2008)
Optimised air-conditioning use	BC Hydro, 2007; Dietz et al., 2009
Reduced hot water use	BC Hydro, 2007
Optimised water heater settings	Dietz et al. (2009); Gardner and Stern (2008)
Replacement of electrical heating/electrical water heaters	Bürger, 2009; Dietz et al. (2009); Huenecke et al. (2010)
Non-residential buildings	
Collective temperature adjustment	-
Keeping windows and/or doors closed	Broc et al., 2006; Matthies and Hansmeier, 2010; Basarir and Overend, 2010
Individual climate regulation	Matthies and Hansmeier, 2010
Turning off lights/computers (electricity conservation)	Junilla, 2008

3.2 GHG abatement potential of selected behavioural changes

From the list of options reported in Section 3.1, three change options were selected for further analysis. The selection was based on data availability, mitigation potential and policy relevance. The selected change options are:

- Reducing space heating temperature (= lowering room temperature).
- Optimising thermostat settings of heating (e.g. leaving room temperatures at the same level, reducing temperature at night/if absent). And
- Optimising ventilation behaviour.

For each of these options, this section will present the maximum realistic GHG mitigation potential.

For reduced space heating temperature, the maximum realistic emission reduction potential is the product of:

- The relative reduction potential per dwelling (which is a function of heating degree days, heating days and the reduction in room temperature).
- The level of insulation and the efficiency of heating systems.
- The share of dwellings without the technical options to reduce the room temperature.
- The share of dwellings with people with special needs concerning temperature levels.
- The overall GHG emissions from space heating.

The second and the third value are time-variant variables. Nevertheless, for the assessment of the reduction potential the actual values of 2010 are used. The effect of an ageing population in some countries is therefore neglected. For the EU the share of households with people with special needs (young children and elderly) is about 35%. It is estimated that 10% of the buildings do not have technical options to control room temperature.

The potential decreases over time, for the overall emission of CO_2 declines until 2050 due to better insulation of houses and improved heating systems.

Table 18 **Maximum realistic GHG mitigation potential of lowering room temperature**

	2020	2030	2050
Reduction of maximum abatement potential (as % of total CO_2 emissions)			
People with special needs	35%	35%	35%
Technical constraints	10%	10%	10%
Realistic maximum abatement potential (as Mt CO_2)			
Reduction by 1°C	22	19	16
Reduction by 2°C	45	38	32

Table 19 shows the maximum realistic mitigation potential of optimising thermostat settings. It highly depends on the possibilities to implement the technical measures to enable users to control their room temperature variant over time. For dwellings with conventional space heating systems, the potential can be fully used, but technical boundary conditions may limit the behavioural change. The potential decreases over time, for the overall emission of CO_2 declines until 2050 due to better insulation of houses and improved heating systems.

Table 19 **Maximum realistic GHG mitigation potential of optimising thermostat settings**

	2020	2030	2050
Reduction of maximum abatement potential (as % of total CO_2 emissions)			
People with special needs	35%	35%	35%
Technical constraints	20%	15%	10%
Realistic potential	52%	55%	59%
Realistic maximum abatement potential (as Mt CO_2)			
Absolute Potential	11	10	9

Table 20 shows the maximum realistic mitigation potential of optimising ventilation. The maximum realistic mitigation potential highly depends on the quality of the building stock. For the future development, more efficient houses will penetrate the market and therefore increase the (relative) effect of ventilation on the overall energy consumption. Nevertheless, if technically advanced systems for automated ventilation become more and more common, the effect of individual behaviour will decrease significantly.
The theoretical reduction potential of the space heating energy demand depends on the composition of the building stock. This reduction mainly depends on the projected diffusion of ventilation technologies in the housing sector. If more advanced technologies would enter the market, the reduction potential would be lower.

Table 20 Maximum realistic GHG mitigation potential of optimising ventilation

	2020	2030	2050
Reduction of maximum abatement potential (as % of total CO_2 emissions)			
Share of passive houses with recuperative ventilation	Not relevant	Not relevant	Relevant
Realistic maximum abatement potential (as Mt CO_2)			
Absolute Potential	43	42	<<42

3.3 Barriers and policies related to domestic energy saving behaviour

In this section we follow an integrated approach for the exploration and discussion of barriers and policy instruments. The three behavioural options at hand are interdependent in the sense, that they aid one another in order to reduce household heat energy consumption. Policy instruments are thus not identified per behavioural mitigation option, but for the combination of behaviours aiming at reducing thermal energy consumption at home.

When considering energy saving behaviour on the household level, a distinction of curtailment and efficiency behaviours must be made, the latter addressing investments in usually high-cost efficiency technologies in buildings. The focus of the report at hand lies on curtailment behaviour, which is driven by daily habits and routines and manifests itself as part of people’s lifestyles: reducing space heating temperature; optimising thermostat settings; optimising ventilation behaviour.

A categorisation of barriers according to a given framework was helpful for identifying common patterns and characteristics for the various behavioural mitigation options (Table 21). To the most important barriers towards residential energy saving belong limited cognition, as lack of knowledge and awareness about one´s own energy consumption. Furthermore, hindering factors can be worldviews that tend to preclude pro-environmental attitudes, comparisons with key other people (that usually act as a driver) or the attribution of responsibility to others, sunk energy costs, plugged-in behavioural routines and the lack of direct energy consumption feedback. Those barriers are usually strongly correlated to some demographic factors, e.g. low income and education or gender differences.

It can be suggested that for several patterns (e.g. particular behavioural routines of different societal groups), specific policy instruments will be helpful; whereas for common patterns that were found to be existing among the public (e.g. lack of knowledge, behavioural concern, social norms, etc.) more general policy instruments may be preferred. As for diffusion patterns, governmental efforts are seen as a first step to act upon people's resistance to change by means of different communication and awareness rising instruments. Packages of policies, including instruments like e.g. financial incentives or provision of consumer feedback, seem to be appropriate to tackle barriers towards household heating energy reduction.

Table 21 Barriers to energy saving behaviour in the housing sector

Barrier category	Examples
Individual (internal) barriers	
Psychological barriers	– No environmental concern – Emotions (e.g. health-related) – No interest in energy-related topics – Political attitudes
	– Risk-assessment: no threat perceived
	– Attribution of responsibility to others – Low self-efficacy – Low behavioural control
Knowledge-based barriers	– Lack of adequate information – Overestimation of own energy savings compared to others
	– Limited knowledge of consumers on their own space heating costs – Believe that no significant savings will occur
Unconscious behaviour	– Strong habits and routines (e.g. no habit to turn down heating)
Demographic factors	– Low income – Younger age – Gender differences
Societal (external) barriers	
Structural and physical barriers	– No possibility to adjust room temperature, install thermostat, open the windows
Cultural barriers	– Comfort is a priority – No social norms towards energy saving; traditions – No social 'competition' or comparison – Social image not related to energy saving
Economic barriers	– Decreasing energy prices – Lack of incentives
Institutional barriers	– Lack of direct consumption feedback – Heating costs included in monthly rent – Incredibleness of experts and authorities – Political barriers

Table 22 presents an overview of policy instruments that can in principle be used to overcome the barriers to energy saving behaviour in the housing sector. Each of these instruments, as well as their advantages and disadvantages, are discussed in more detail in the housing domain report.

Table 22 **Policies addressing barriers to energy saving behaviour in the housing sector**

Policy category	Examples
Regulative instruments	– Mandatory heating energy billing at frequent intervals – More informative heating energy billing – Mandatory energy performance certificates with real display orientation – Obligation to include information in formal education
Economic instruments	– Higher energy prices – Taxation of high energy consumption – Subsidies e.g. on purchase of smart metering equipment or set-back thermometers – Incentives for energy efficient, adjustable heating infrastructure
Communication	– Information campaigns (large scale; demonstration projects; informal advice networks; community progr.) – Communicate best practices – Communicate the direct link between GHG reduction and space heating consumption – Creating ICT-based energy efficiency evaluation tools
Direct governmental expenditures	– Public investments in infrastructure, like smart meters
Procedural instruments	– Voluntary agreements with companies, schools, etc. – Voluntary contracting agreements with ESCO's

To address the identified barriers a selection of appropriate policies has been defined. They cover all the instrument types mentioned above except from the procedural instruments (voluntary agreements might in single cases pertain to rendering energy bills more efficient or installing smart metering appliances, but they usually do not directly aim at end-users).

Communication is crucial to achieve the targets; without, government expenditures in new technologies are without effect, for the technology itself does not change behaviour. Even higher energy prices as an economic instrument cannot be fully successful without having addressed the knowledge-based and habitual barriers.

An effective policy package therefore comprises a strong informational focus. The EU could be a role model by arranging wide-spread key campaigns and carry behavioural change messages to large samples of households; however nation- and especially region-wide initiatives play a major role due to their target-group approach. Mounting campaigns on all levels is therefore highly recommendable. Those communicative elements are best accompanied by regulatory incentives or subsidies for equipment such as smart meters which enhance user information as well as devices like electronic thermostats, which allow improved thermostat settings.

The information gap can be filled by detailed billing including a benchmark of the individual energetic performance.

Finally as an option, energy taxes can have a strong impetus on user behaviour.

3.4 Conclusion

Behavioural changes in housing may lead to lower GHG emissions in the EU. Changing room temperatures could maximally result in a reduction 45 Mt CO_2 in 2020, relative to the PRIMES/GAINS reference projection, and 32Mt in 2050, when houses will be better insulated and heating systems will have become more efficient. However, these figures assume that the maximum realistic abatement potential is reached, meaning, for example, that all consumers who in principle can lower their room temperature will do so.

There are barriers currently withholding households to implement behavioural changes. The most important barriers towards residential energy saving are psychological ones, namely limited cognition, as lack of knowledge and awareness about one´s own energy consumption.

To address those barriers, a policy package consisting of informational and regulative instruments as well as subsidies and raised energy prices has been defined. The impact of widespread informational policy instruments will result in a realisation of up to one third of the realistic potentials. The impact of financial Instruments on user behaviour is considered in the price sensitivity of the models.

4 Food and drink

4.1 Overview of behavioural changes

Behavioural change options that reduce GHG emissions fall into six categories (Table 23):

1. Change to a vegetarian diet: various studies find that GHG emissions associated with meat are much higher than emissions associated with plant protein sources. Hence, a change to a vegetarian diet would reduce GHG emissions.
2. Reduction of animal protein intake: dairy and egg have GHG emissions similar to meat. Hence, a reduction of animal protein intake would reduce GHG emissions.
3. Healthy diet: fewer calories, more fruit and vegetables. EU citizens, on average, consume more than recommended by e.g. the World Health Organisation. Moreover, they consume fewer fruit and vegetables than recommended. Changing to a healthy diet would thus reduce the overall food consumption and could also reduce the consumption of animal products, thus lowering GHG emissions.
4. Reducing food waste: food wastage can be divided into the category of unavoidable waste (unedible remains) and waste which could be avoided (throwing away expired food, leaving edible food on the plate). By reducing waste, the total food consumption is reduced and also are GHG emissions.
5. A larger share of local and seasonal food, reducing food imports: a few literature sources pay attention to the fact that local and seasonal food has on average lower GHG emission intensity. Some vegetables grown in greenhouses and products which are transported over long distances require more energy input in their life cycle than locally produced and/or seasonal food.
6. Reducing energy and fuel use: another set of options related to the food sector would be reducing energy and fuel use. Energy use related to food in households can be cut the most by using more energy-efficient cooling appliances and placing them in cool places such as a cellar. Fuel use can be reduced by more intensive use of the home delivery of groceries service. It is evident that products involving more transport, storage and cooling require more energy input and therefore, generate more GHG emissions. Likewise, food preparation methods may result in GHG emissions.

Table 23 Overview of behavioural change options in the food domain

Behavioural measure
Change to a vegetarian diet
Reduction of animal protein intake
Healthy diet, less calories
Reducing food waste
More local and seasonal food, reducing import of food
Reducing energy and fuel use during shopping, preparation and storage of food

4.2 Impacts of selected behavioural changes on GHG emissions

From the list of options reported in Section 4.1, three change options were selected for further analysis. The selection was based on data availability, mitigation potential and policy relevance. The selected change options are:

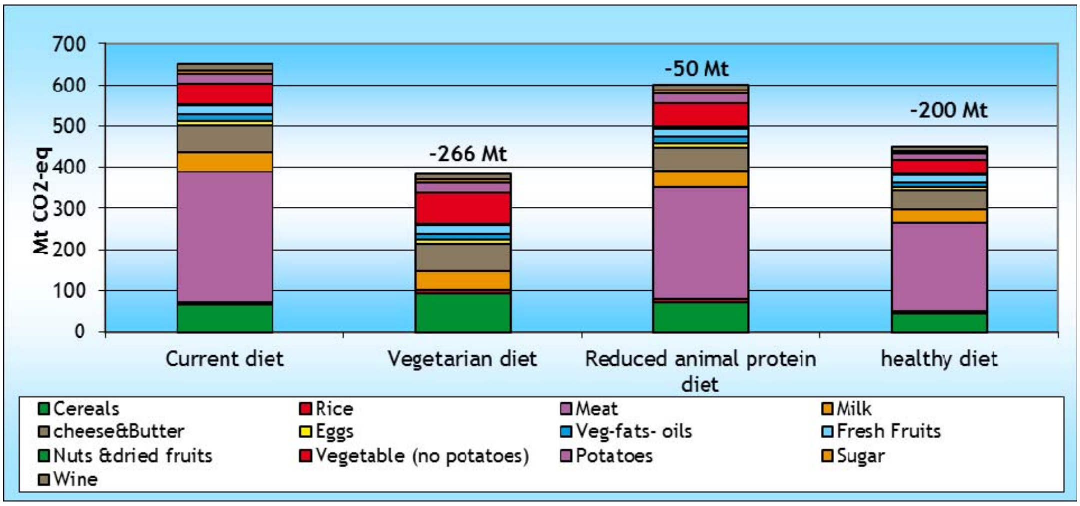
- Vegetarian diet: no consumption of meat, fish or sea food. The calorie intake is constant, meat, fish and sea food are replaced by calorie-equivalent amounts of grains, legumes and vegetables. All other categories including dairy products and eggs remain unchanged.
- Reducing all animal protein intake including dairy and eggs: one day without animal proteins. The consumption of meat, fish, sea food, dairy products and eggs is reduced by 14%. As in the vegetarian diet, the calorie intake is constant. Animal proteins are replaced by calorie-equivalent amounts of grains, legumes and vegetables.
- Reducing intake to a healthy level (calories, overall protein): reducing daily intake to 2,500 kilocalories and eating 500 grams of fruits and vegetables, in line with WHO/FAO recommendations. This in turn limits the total fat to 30% of caloric intake and saturated fatty acids to 10%, reducing sugar intake to 10% of total caloric intake and limiting salt intake to a maximum of 5 grams per day.

For each of these options, this section will present the maximum realistic GHG mitigation potential. This potential has been derived in a different way than in Section 1.5.1. The differences are:

- Because there are few, if any, direct emissions associated with the consumption of different food items, life cycle emissions are taken into account. In case some of these emissions may occur from outside the EU, the estimated share of non-EU emissions is presented separately.
- Because life cycle emissions are assessed, indirect effects are included and not reported separately.
- There are no data on rebound effects of dietary choices within the food sector. Hence, they are ignored.
- Because of lack of an agreed diet baseline, diets (in terms of kg/head) are assumed to remain constant. Hence, total emissions change with population only.

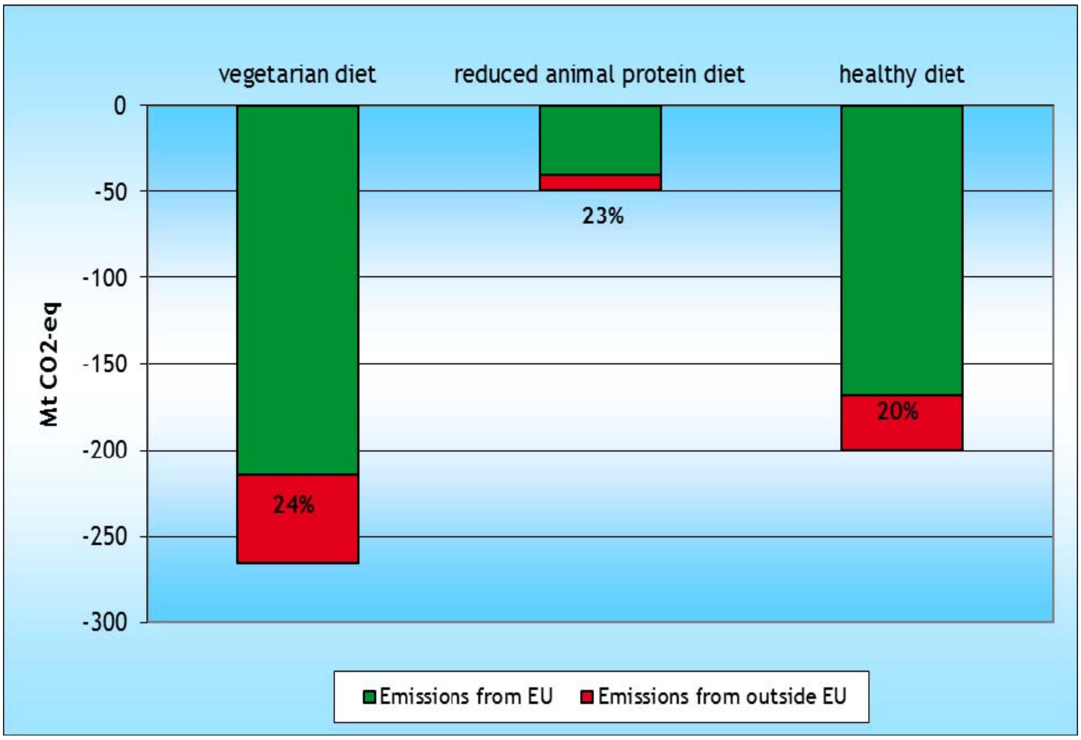
The reduction potential of a vegetarian diet is larger than that of the other two diets, mainly because almost half of the emissions from the current diet are associated with meat consumption. Healthy eating results in a somewhat smaller reduction in emissions, while a 14% reduction in animal protein has the smallest abatement potential of the dietary changes considered (Figure 8).

Figure 8 Total climate impact in current and selected diets in 2020, Mt of CO_2 eq.



In all dietary changes considered, most of the emission reductions occur in the EU. The share of emission reductions outside the EU varies from 20% for the healthy diet option to 24% for the vegetarian diet.

Figure 9 Total reductions in GHGs due to diet shifts in 2020, with division into EU and non-EU emissions



4.3 Barriers and policies related to vegetarian and reduced animal protein diet

For vegetarian and reduced animal protein diets, knowledge, habits and cultural barriers are the most important barriers. It is likely that, once knowledge levels, habits and culinary cultures have changed, products for meat and animal protein products will become available in the food service sector and in meals and products that are ready-made and easy to produce. Situational and infrastructural barriers are less important than knowledge, habits and cultural barriers.

One important question is whether the barriers are equally important for a vegetarian diet and a reduced animal protein diet. Because changing to a vegetarian diet constitutes a big change as compared to most consumers' current diets, whereas reducing animal protein intake to six days a week constitutes a more limited change and essentially leaves the diet intact on six out of seven days, we assume that habits and cultural barriers are slightly more important for a vegetarian diet than for reducing animal protein intake.

Table 24 Ranking of the barriers based on their relative impact for vegetarian and reduced animal protein diet

Barrier category	Examples
Individual (internal) barriers	
Knowledge-based barriers	– Consumers can sometimes be confused by the use of different terminologies, such as organic, green, natural or environmentally friendly – Consumers have little knowledge as to what is sustainable and what is not – Consumers are not aware of the environmental effects of meat consumption
Unconscious behaviour	– Dietary choices are often habitual
Societal (external) barriers	
Structural and physical barriers	– In the food-service sector (restaurants, cafés, street vendors) the availability of substitution products may be a problem
Cultural barriers	– Meat is a vital part of culinary cultures in Europe – Many people see meat as an essential part of the meal

Knowledge based barriers can be addressed through communication, e.g. mass media campaigns and food labelling. However, there is still the fact that food choices are in large part habitual. A first relevant policy instrument that addresses this consists of school-based intervention programs. Habits develop early in life, and it is therefore important to help children develop healthy and sustainable habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as charging meat/animal protein consumption with consumption taxes. Table 25 provides an overview of policy measures to overcome barriers to vegetarian diet change or reducing animal protein intake.

Table 25 **Overview of policy measures to overcome barriers to vegetarian diet change or reducing animal protein intake**

Policy category	Examples
Economic instruments	– Meat tax – Animal protein tax
Communication	– School based interventions – Mass media campaigns – Food product labelling

Based on the analysis of barriers and policy instruments we composed for further examination (in close agreement with the Commission) a policy package for a reduction of animal protein consumption. This policy package comprises two policies for which empirical evidence on effectiveness exists:

- An animal protein tax or excise duty;
- A label conveying information about the GHG emissions associated with the food product.

A rough estimate of the effectiveness (in terms of CO_2e reductions) of the entire policy package is presented in Table 10. Both the CO_2 impacts of the individual policy instruments as the CO_2 impact of the entire policy package is presented.

Table 26 **Rough estimation of the relative CO_2 reductions policies to reduce animal protein consumption**

Policy (package)	CO_2 reduction due to smaller cars
Animal protein tax or excise duty	5.0%
GHG emissions labelling	0.5%
Policy package	5.5%

Note: Due to possible interaction effects, the CO_2 impacts of individual policy instruments do not necessarily add up to the CO_2 impacts of the various policy packages.

Implementation of the proposed policy package would result in 5.5% lower life cycle CO_2e emissions associated with food consumption. In 2020, this amounts to 3 Mt CO_2e, of which 2 Mt CO_2e in the EU.

4.4 Barriers and policies related to healthy diet

For healthy diets, knowledge about the healthiness of specific products, habits, socio-economic status, the obesogenic environment and economic barriers conspire to make healthy choices very hard. All of these barriers are important, although one can argue that economic barriers are less important than the other barriers, because food products are mostly very price-inelastic (OECD, 2010).

Table 27 **Ranking of the barriers based on their relative impact for healthy consumption**

Barrier category	Examples
Individual (internal) barriers	
Knowledge-based barriers	– Adequate knowledge at the product level is limited: consumers have difficulties determining which specific products are healthy and which are not
Unconscious behaviour	– Dietary choices are often habitual
Societal (external) barriers	
Structural and physical barriers	– Abundant availability of unhealthy products creates an 'obesogenic environment'
Economic barriers	– Healthy diets are on average more expensive that unhealthy diets

As Table 27 shows, knowledge, habits, socio-economic status, infrastructural and economic factors are the most important barriers for a change to a healthy diet. It is unlikely that these barriers can be overcome in the short term, but on the long-term educational interventions and laws can slowly nudge people in the proposed direction. Policy instruments that can be considered include mandatory nutrition labelling, containing nutritional information of all food products; school-based intervention programs; and consumption taxes. The latter instrument goes some way to also tackle the economic barriers to healthy consumption and the barrier that is posed by socio-economic status.

Table 28 **Overview of policy measures to overcome barriers to a healthy diet**

Policy category	Examples
Economic instruments	– Consumption taxes
Communication	– Food product labelling – School-based interventions

Based on the analysis of barriers and policy instruments we composed for further examination (in close agreement with the Commission) a policy package for a change to a more healthy diet. This policy package comprises three policies for which empirical evidence on effectiveness exists:
- health labels;
- mass media campaigns to promote a healthy diet;
- school based intervention offering healthy diets in school canteens and educating pupils about healthy diets;
- an differentiated tax or excise duty (lower taxes on fresh fruit and vegetables, higher taxes on fats).

A rough estimate of the effectiveness (in terms of CO_2e reductions) of the entire policy package is presented in Table 10. Both the CO_2 impacts of the individual policy instruments as the CO_2 impact of the entire policy package is presented. As the share of the population that has been reached by the school-based interventions grows, the effect of the policy package increases.

Table 29 **Rough estimate of the relative CO_2 reductions policies to reduce animal protein consumption**

policy measure	2020	2030	2050
Labelling	7.5%	7.5%	7.5%
Mass media campaigns	10%	10%	10%
School-based intervention	3.4%	5.7%	10.4%
VAT and excises	3%	3%	3%
Total impact (= reduction of difference in consumption of food products between current diet and healthy diet	20%	22%	26%

Implementation of the proposed policy package result in 22% lower life cycle CO_2e emissions associated with food consumption in 2020, increasing to 28% in 2050. In 2020, this amounts to 44 Mt CO_2e, of which 37 Mt CO_2e in the EU, increasing to 56 Mt CO_2e in 2050, of which 47 Mt CO_2e in the EU.

4.5 Conclusion

Changes in dietary choices may lead to lower GHG emissions in the EU. A completely vegetarian diet could maximally result in a reduction 266 Mt CO_2 eq., of which 209 Mt CO_2 eq. in the EU. A day without animal proteins could reduce emissions by 50 Mt CO_2 eq., of which 39 Mt CO_2 eq. in the EU. And a shift to a healthy diet, with fewer calories and more fruit and vegetables than the current diet could result in a reduction of emissions of 195 Mt CO_2 eq., of which 200 Mt CO_2 eq. in the EU. However, these figures assume that the maximum realistic abatement potential is reached, meaning, for example, that all consumers switch to a certain diet.

There are barriers currently withholding consumers to change their diets. The most important barriers are a lack of knowledge on the environmental or health impacts of food products and the strong cultural norms that affect dietary choices. Moreover, diets have a strong habitual component.

To address these barriers, informational and economic policies can be used. The assessment of policies aimed at reducing the climate impact of diets is hampered by the scarce availability of empirical data on their effectiveness. More studies are available on policies to incentivise a shift to a healthy diet. Based on these studies, we estimate that a policy package aimed at a more healthy diet could reduce the climate impact of the EU diet by about a quarter.

5 Conclusions

Behavioural changes can result in a considerable reduction of GHG emissions in the EU. This study has assessed the maximum realistic abatement potential of 11 behavioural changes. If implemented by all the households and/or consumers which can reasonably be expected to be able to do so, their impact on EU GHG emissions would range from 22 Mt CO_2 in 2020 (a reduction of space heating temperature by 1°C) to almost 266 Mt CO_2 in 2020 (a shift to a vegetarian diet). By 2050, the reduction potential would range from 10 Mt CO_2 (fuel efficient driving style) to 462 Mt CO_2 (buying and using electric cars).

Not all measures can be implemented simultaneously and hence the maximum realistic mitigation potentials are not additive. The maximum realistic abatement potential of the measures that can be implemented simultaneously amounts maximally to about 600 Mt CO_2 in 2020, which is about a quarter of the projected emissions in the non-ETS sector.

Many behavioural change options have negative direct costs. This study has not assessed the welfare costs of these measures, which would often be positive.

Most behavioural changes are inhibited by barriers. In many cases, social and cultural norms inhibit behavioural change. For example, a change to a vegetarian diet is held back by norms prescribing that a meal should contain meat or fish. Knowledge barriers are also important. For example, the most important barriers towards residential energy saving are limited cognition, as lack of knowledge and awareness about one's own energy consumption.

Barriers can be overcome partially or fully by policies. Knowledge barriers can be overcome by communication, voluntary agreements and regulative instruments such as labelling. Habits can be addressed by economic instruments and, in the case of dietary choices, school based intervention.

In a few cases, the effects of policy packages and their costs have been quantified.

For example, in order to increase the purchase and use of smaller cars, a policy package has been designed comprising of the following instruments:
- a CO_2 differentiated purchase tax;
- a CO_2 differentiated company car tax;
- a (CO_2 differentiated) increase of fuel taxes;
- spatial policies favourable to smaller cars;
- a supportive communication strategy.

This policy package could in the longer term reduce CO_2 emissions per passenger kilometre by 6-9%. This would correspond to 24–35 Mt in 2050. If the additional effect of higher taxes on car purchases and transport demand is taken into account, emissions would decrease by 16-25%.

This policy package relies to a large extent on tax measures, which would require unanimity among Member States to be introduced at an EU level, and whose effect may not be fully realised due to interactions with the existing CO2 and cars regulation.

A policy package to incentivise a shift towards a healthy diet could comprise of the following instruments:
- mandatory nutrition labelling;
- mass media campaigns;
- school-based intervention;
- differentiated taxes and excise duties.

This policy package could reduce dietary emissions by 22% in 2020 increasing to 28% in 2050 as more people have experienced the school based intervention. In 2020, this amounts to 44 Mt CO_2e, of which 37 Mt CO_2e in the EU, increasing to 56 Mt CO_2e in 2050, of which 47 Mt CO_2e in the EU. The EU share amounts to about 2% of non-ETS emissions. This package relies on various policy instruments, many of which could be introduced at an EU level. The differentiated tax, which would require unanimity among Member States, accounts for a relatively small share of the effect.

In many cases, however, it has not been possible to quantitatively assess the impact of policy packages. There is scarce empirical evidence on the impact of policies on reducing room temperature, optimising ventilation, teleworking and reducing animal protein intake, for example.

Many policy packages identified in this report would require concerted action at EU and Member State levels.

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