Household and economy wide impacts of changing environmental behaviours

A research report completed for the Department for Environment, Food and Rural Affairs by AEA, PSI and Metroeconomica

September 2009

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Department for Environment Food and Rural Affairs

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Final Report to the Department for Environment Food and Rural Affairs

September 2009

Suggested citation for this report:

AEA, Policy Studies Institute and Metroeconomica (2009) *Household and economy wide impacts of changing environmental behaviours: A report to the Department for Environment, Food and Rural Affairs.* Defra, London.

Note:

The annexes of the report can be found in a separate document.

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Glossary

CBA	Cost benefit analysis	*Analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value*
CEA	Cost effectiveness analysis	*An analysis that compares the costs (and benefits) of different projects or policy interventions against a common objective, in this case reducing CO_2e emissions. An intervention is deemed to be cost-effective if it is below the Government's projection for EU ETS allowances (in the case of traded sector emissions savings), or below projections for the Shadow Price of Carbon (in the case of non-traded sector emissions savings).*
CO_2	Carbon dioxide	*One of the main greenhouse gases and particularly relevant to the consumption of energy, as it is emitted by the combustion of fossil fuels.*
CO_2e	Carbon dioxide equivalent	*Different GHGs have different potentials to contribute to global warming, which can be compared to the equivalent impact of one tonne of CO_2. CO_2e is an expression of the total amount of greenhouse gases expressed in terms of their CO_2 equivalent.*
Defra	Department for Environment, Food and Rural Affairs	
EA	Environment Agency	
GHG	Greenhouse gas	*The gases that contribute to global warming and climate change by enhancing the Earth's natural greenhouse effect.*
MAC	Marginal abatement cost	*The cost or cost saving of reducing emissions by one tonne of CO_2e.*
NPV	Net present value	*A means of presenting the outcome of a cost benefit analysis (CBA). Projects or policy interventions with a negative NPV should not usually be recommended (unless there are positive effects not included in the CBA which might make the project/policy worthwhile).*
	Rebound effects	*Second order, knock-on effects on household behaviour (and therefore CO_2e emissions) of first order behavioural change.*

Sacrifice of service	*This refers to the case where a householder, say, substitutes one action for an alternative, which might save money, but other services (benefits) are sacrificed at the same time.*

Executive Summary

This is the final report of a project entitled '*Household and economy wide impacts of changing environmental behaviours*'[1] that commenced in January 2008. Its main aim (Objective 1) was to assess the direct costs, benefits and carbon dioxide equivalent (CO_2e) abatement potential of selected pro-environmental behaviours in England. Additionally, there were two supplementary objectives that were more conceptual in nature: Objective 2 assessed the feasibility of modelling the indirect effects on CO_2e of changes in households' expenditure patterns as a result of behavioural changes; whilst Objective 3 reviewed potential subsequent wider impacts on the economy. The high level objective of the report is to identify an initial (order of magnitude) estimate of what the aspirational goals in the pro-environmental behaviours framework may deliver in terms of aggregate environmental improvement, with a focus on CO_2e emissions.

The twelve pro-environmental behaviours to be assessed had been identified by earlier Defra work with internal and external stakeholder input:

- **Energy**: "Install insulation"; "Buy energy efficient products"; "Better energy management in the home" and "Install domestic micro-generation";
- **Transport**: "Use more low energy consuming vehicles"; "Use car less/Seek alternatives for journeys of 3 miles or less"; "Avoid unnecessary flights (short haul)";
- **Food**: "Eat more food that is locally in season" and "Adopt a low impact diet" and "Waste less food";
- **Water**: "More responsible water usage"; and
- **Waste**: "Increase recycling and segregation".

Data on the costs, benefits and CO_2e abatement potential of actions that might underlie these behaviours were identified from existing literature and compiled in order to be modelled in a series of Excel spreadsheets. Estimates of costs, benefits and abatement potential of behavioural actions in three scenarios were compared against a baseline in which planned policies deliver as anticipated. The three scenarios were:

- A ***limited response*** scenario in which existing policies did not fully deliver as anticipated.
- Illustrative ***concerted*** and ***far reaching*** scenarios representing different levels of potential uptake of the actions that might result from the adoption of each of the headline behaviour goals.

[1] It was undertaken by a team led by AEA supported by Policy Studies Institute, Metroeconomica

The uptake under the latter two scenarios was informed by Defra's model that segments the population by its propensity to adopt pro-environmental behaviours[2]. The scenario model developed by the project was submitted to Defra as one of the project's outputs. It is designed to be transparent and allow for easy input of updated data and assumptions to enable the modelling of alternative scenarios.

Results should be seen to be ***indicative*** only for the following reasons:

- The scope and timescale only facilitated the development of a relatively simple model that required a significant number of **high level assumptions**;
- The **illustrative uptake scenarios only represent plausible levels of behavioural change** based on people's ability and indicated willingness to act;
- The **cost estimates are based on 'typical' or 'average' household costs**; clearly the impacts for a particular household will vary according to its size, type, location and state of the dwelling. The impact of changes in behaviour will also depend on a household's existing profile with respect to the behaviour in question, e.g. its existing level of insulation or travel patterns;
- Similarly, **no attempt was made to estimate any wider costs and benefits of behavioural change**, e.g. impacts on the wider economy. This was considered conceptually under Objective 3 (see Section 6).

The results are potentially underestimated as:

- Some of the headline behaviour goals are relatively vague, so it was necessary to identify the actions that might be adopted under each of the goals in order to identify the associated costs, benefits and abatement potential. However, in many cases, **it was not possible to identify a comprehensive set of actions**, so only a subset of the possible actions that could contribute to each of the behaviours was considered. Hence, the results are necessarily partial;
- It was **not possible to identify a comprehensive set of quantified estimates for non-CO_2e benefits**, e.g. of health and environmental benefits. Consequently, the model does not include any such estimates, so the results potentially underestimate the impacts of some of the behaviours;
- It was generally assumed that the **direct financial costs identified would not change over time**, whereas it is likely that these will change, particularly through technological development and economies of scale;
- The potential for the adoption of one of the behaviours **to catalyse the uptake of others** has not been captured within the scenarios.

[2] Defra (2008) *A Framework for Pro-environmental behaviours* January 2008; see http://www.defra.gov.uk/evidence/social/behaviour/index.htm

On the other hand, the results could be overestimating the impacts of adopting the headline behaviour goals as:

- **Some of the behaviours are closely linked**, so the potential benefits of one might influence the impact of another. Whilst care was taken to take account of any subsequent overlaps, it is likely that some benefits have still been overstated;
- The **project made no attempt to quantify the barriers to uptake**. The illustrative uptake scenarios were restricted by a judgement of what could plausibly be overcome over time. It is likely that barriers will be significant, particularly for the *far reaching* scenario. However, it was not possible to explore these barriers in detail;
- The project has attempted to estimate first order costs and benefits only. Hence, **no attempt was made to quantify second order, rebound effects**, as the consideration of indirect effects was outside of the scope of the project. Instead, the feasibility of modelling these was considered under Objective 2 (see Section 5).

It is difficult to assess the extent to which the caveats that might result in an overestimation of any benefits are balanced by those that might result in an underestimation. However, it is worth noting that the barriers to uptake that were not quantified might be some of the most important factors preventing the adoption of a behaviour and hence, in such cases, it is more likely that the results are overestimates.

Consequently, different levels of confidence can be expressed in the results associated with the different headline behaviour goals. Most confidence can be put in the results for three of the four energy behaviours: ***"install insulation"***; ***"buy energy efficient products"*** and ***"install domestic micro-generation"***. This is because the data underlying these are taken from sources produced either for, or by, government departments and agencies, which have already been used for policy assessment. The approach taken and results for these three headline behaviour goals are, therefore, presented in more detail in Section 3.

Less confidence can be expressed in the results of the estimates associated with the other nine behaviours. Indeed, for one of the behaviours – ***"avoid unnecessary flights (short haul)"*** –it was decided that it was not possible to determine in any meaningful way what this behaviour meant in practice, i.e. what an 'unnecessary' flight was (a more specific definition, for future analysis, could be ***"making smarter flight choices"***[3]). Hence, no assessment was undertaken for this behaviour. For the other eight behaviours, a judgement was required as to which data to use to develop the scenarios. Hence, in light of the relative lack of confidence in these other eight headline behaviour goals, not to mention the caveats noted above, the results for these behaviours are discussed and presented only at an aggregate level. However, presenting the results in this way enables the first order estimates of the potential benefits of household behavioural change to be discussed.

[3] Where viable transport alternatives exist.

CO_2e savings achieved in the UK can either be in the traded or non-traded sectors. The traded sector refers to those emissions covered by the EU Emissions Trading Scheme (ETS), for which there is an EU-level central cap on CO_2e emissions, and participating plants have permits to emit CO_2e and can trade emissions allowances, as necessary. Due to the centrally set cap, reducing CO_2e emissions from one source means that higher emissions will be allowed elsewhere in the system, but this CO_2e abatement helps to meet the overall EU ETS cap, reduces the costs of delivering the emissions reductions in the EU ETS and often these savings would be highly cost-effective compared to other potential actions. CO_2e emissions in the UK that are not covered by the EU ETS (such as those from road transport powered by fossil fuels, or domestic gas use) are referred to as being in the 'non-traded sector'. CO_2e abatement in the non-traded sector results in definite reductions in emissions and will therefore have an environmental benefit.

The illustrative *concerted* uptake scenario developed for this project suggests that there is the potential to deliver an additional 60 million tonnes (Mt) of CO_2e abatement in England in the non-traded sectors between 2007 and 2020, if the headline behaviour goals were adopted at the levels assumed for this scenario (as shown in Table 2-1). This takes the actual take-up of these behaviours in 2007 as the base year starting point to assess how the

Table 1-1: Indicative Potential for Cumulative Savings in CO_2e Emissions (between 2007 and 2020) from adopting the pro-environmental behaviours, in addition to existing policies[4]

	Emissions savings within EU ETS cap (traded sector)	**Emissions reductions not covered by EU ETS (non-traded sector)**	**Emissions reduction in the covered and not covered by EU ETS**
Concerted Scenario	65 $MtCO_2e$ *(40 – 75 $MtCO_2e$)**	60 $MtCO_2e$ *(40 -70 $MtCO_2e$)**	**120 $MtCO_2e$** ***(80 - 140 $MtCO_2e$)****
Far reaching Scenario	100 $MtCO_2e$ *(55 - 130 $MtCO_2e$)**	180 $MtCO_2e$ *(95 - 230 $MtCO_2e$)**	**280 $MtCO_2e$** ***(150 - 355 $MtCO_2e$)****
Total (concerted + far reaching)	**165 $MtCO_2e$** ***(90 - 200 $MtCO_2e$)****	**235 $MtCO_2e$** ***(135 -300 $MtCO_2e$)****	**400 $MtCO_2e$** ***(230 - 495 $MtCO_2e$)****

*Note that the figures in brackets are indicative ranges within which the central estimate might vary. These are based on an assessment if the potential impacts of the caveats on the central estimates. They should not be taken to represent statistical significance, for example.

[4] Numbers do not add up in all cases due to rounding.

take-up of the behaviours could increase to 2020. Taking account of the caveats noted above, the potential CO_2e savings under the illustrative *concerted* scenario in the non-traded sectors might be as low as 40 $MtCO_2e$ or as high as 70 $MtCO_2e$ depending on the relative impacts of the unquantified elements. Similarly, there is the potential to deliver nearly 65 $MtCO_2e$ of abatement in the traded sector in England, additional to planned policies, if the headline behaviour goals were adopted at the assumed levels, with a range of 40 $MtCO_2e$ to 75 $MtCO_2e$. Under the illustrative *far reaching* scenario, there is the potential for around 100 $MtCO_2e$ of additional abatement in the traded sector during this period and nearly 180 $MtCO_2e$ in the non-traded sectors (see Table 1-1).

Taken together, the assessment suggests that changing household behaviours has the potential to deliver around 235 $MtCO_2e$ reductions in non-traded sectors in England, on top of planned policies, which is equivalent to around 3.3% of the UK's annual emissions of CO_2e emissions. This is on top of the nearly 160 $MtCO_2e$ that could be delivered between 2007 and 2020 if planned policies deliver as anticipated, of which more than half would occur in non-traded sectors.

The potential CO_2e emissions savings in 2020 in England that could be delivered under the illustrative *concerted* and *far reaching* scenarios could be around 50 $MtCO_2e$, although within a range from 30 $MtCO_2e$ to 60 $MtCO_2e$ taking into account the caveats noted above. More than half of this total would be due to savings in the non-traded sectors, and the majority of the savings would be delivered by the *far reaching* scenario.

Table 1-2: Indicative Potential for Savings for 2020 in CO_2e Emissions from adopting the pro-environmental behaviours, in addition to existing policies[5]

	Emissions savings within EU ETS cap (traded sector)	**Emissions reductions not covered by EU ETS (non-traded sector)**	**Emissions reduction in the covered and not covered by EU ETS**
Concerted Scenario	10 $MtCO_2e$ *(5 – 10 $MtCO_2e$)**	10 $MtCO_2e$ *(5 -10 $MtCO_2e$)**	**15 $MtCO_2e$** ***(10 - 15 $MtCO_2e$)****
Far reaching Scenario	15 $MtCO_2e$ *(5 - 15 $MtCO_2e$)**	25 $MtCO_2e$ *(10 - 30 $MtCO_2e$)**	**35 $MtCO_2e$** ***(20 - 45 $MtCO_2e$)****
Total (concerted + far reaching)	**25 $MtCO_2e$** ***(10 - 25 $MtCO_2e$)****	**30 $MtCO_2e$** ***(15 -35 $MtCO_2e$)****	**50 $MtCO_2e$** ***(30 - 60 $MtCO_2e$)****

*Note that the figures in brackets are indicative ranges within which the central estimate might vary. These are based on an assessment if the potential impacts of the caveats on the central estimates. They should not be taken to represent statistical significance, for example.

[5] Numbers do not add up in all cases due to rounding.

Any potential emissions reductions achieved in the traded sector would help the UK to meet its emission reduction targets under the EU ETS; often these savings would be highly cost-effective compared to other actions (and most importantly, when *compared to the price of EU ETS allowances)*. It is important to note that such emission reductions are beneficial in other ways, as they would potentially increase the revenue that the UK receives from the sale of EU ETS allowances and also reduce the emissions baseline of the electricity generation industry, thus enabling stricter emissions targets in the longer-term.

Around 80% of the maximum potential additional reduction of CO_2e emissions (i.e. that delivered under both the *concerted* and *far reaching* scenarios) would be delivered by the behaviours for which there are lower levels of confidence in the results (see Figure 4-1). Also, it is important to note that not all of the emissions saved will necessarily be in the UK; for example, increasing recycling levels in the UK could lead to reductions in CO_2e emissions in other countries.

If an individual household were to adopt the actions that might result from behavioural change, there is the potential for an ***average household*** to save more than £2,100 a year (see Figure 4-3). The figure assumes that the household adopts all the actions listed in Table 2-1 that are possible (i.e. those that are neither mutually exclusive nor overlapping) and, critically, that it was not previously undertaking any of these. The potential savings result from lower food bills, lower transport fuel bills, lower household energy bills and lower water bills (for those households that are metered for water). The potential benefit for a ***particular household*** will depend on a range of factors, such as the size of the dwelling and the usage of the various products and services. Just over £300 of this saving is from the adoption of the energy behaviours in which there was more confidence; the remainder comes from the adoption of the other eight quantified behaviours for which we have less confidence in the data and results. Hence, there is a fair degree of uncertainty associated with the maximum potential savings.

It is important to note that the quantification and inclusion of the various missing non-financial costs and benefits could significantly impact on the overall results. For example, the inclusion of health benefits could significantly improve the performance of some of the behaviours, which suggests that the results for the relevant behaviours, e.g. ***"adopt a low impact diet"*** and ***"use car less"***, might be underestimated. On the other hand, for the same behaviours, there are significant barriers (including the level of service provided), such as the need for additional planning of journeys and diet, to be overcome that increase the costs associated with the respective headline behaviour goals.

If indirect effects were modelled (as set out by Objective 2), it is likely that the benefits of all the behaviours where financial savings occur would be reduced. This highlights the need for pro-environmental behaviour change strategies to promote and catalyse behavioural change in all relevant areas of consumption. Although further research is required in this area, it seems likely that a future well designed pro-environmental behaviour change strategy will need to engage people on their environmental preferences, or risk delivering only a marginal overall emission reduction. The inclusion of the costs and benefits to the wider economy (as

discussed in Objective 3) would also have an impact on the results that is difficult to determine without additional research. Finally, the benefits of behaviours (and level of uptake) will be affected by relative price levels; increases in fossil fuel and food prices would magnify these benefits.

In order to take forward its work on environmental behaviours, it is suggested that it would be helpful for Defra to commission further research on a range of topics associated with the full and proper representation of non-market costs and benefits. Additionally, a better understanding of the impacts and benefits of some of the behaviours is needed, as is a better understanding of how barriers could be overcome.

1 Introduction

1.1 Personal consumption is responsible for a large proportion of the pressures on the environment, both in the UK and abroad. UK households are responsible for 42% of the country's carbon dioxide (CO_2) emissions (including their car use); use 50% of the water abstracted by water companies;[6] and dispose of 15% of its controlled waste. In addition to these direct impacts, there are indirect impacts caused by the manufacture of the products that households consume. These indirect impacts could be in the UK or abroad, and could impact on the quality of air or water resources, or on natural resources and biodiversity (Defra, 2008). In 2007, CO_2 emissions from the UK residential sector, i.e. households, totalled 142.2 million tonnes (Mt) of CO_2, while the transport sector, which includes household car use as well as freight transport, emitted 153.2 MtCO_2[7].

1.2 Consequently, by changing the behaviour of households, there is the potential to reduce adverse environmental impacts, both in the UK and abroad, including reducing emissions of CO_2. In 2006, Defra published a scoping report on the development of an environmental behaviours strategy, which reviewed the scale of the challenge, current practice and understanding and took the first steps towards the identification of possible policy actions[8]. The report also identified a long list of environmental behaviours that households might adopt and initiated work on the segmentation of the population by the propensity to adopt these behaviours. The latter is important in helping to target policies, as different households will be more, or less, willing to act than others, and so will respond to different types of policy measure (Defra, 2006).

1.3 The work on headline behaviours and population segmentation was taken forward in the course of 2007 and reported by Defra in January 2008[9]. This report sets out a framework for Defra's work on pro-environmental behaviours by bringing together evidence on public understanding, attitudes and behaviours. Additionally, it

[6] i.e. half of all water abstracted from the environment

[7] See http://www.defra.gov.uk/environment/statistics/globatmos/alltables.htm, Table 5, end user statistics; accessed 25/08/09

[8] Defra (2006) *An environmental behaviours strategy for Defra* December 2006; see http://www.defra.gov.uk/evidence/social/behaviour/index.htm

[9] Defra (2008) *A Framework for Pro-environmental behaviours* January 2008; see http://www.defra.gov.uk/evidence/social/behaviour/index.htm

identified ***twelve headline behaviour goals*** that could be the focus of policy attention aimed at encouraging households to change their behaviour. These were:

- **Four energy headline behaviour goals**: "install insulation"; "buy energy efficient products"; "better energy management in the home" and "install domestic micro-generation";
- **Three transport headline behaviour goals**: "use more low energy consuming vehicles"; "use car less[10]" and "avoid unnecessary flights (short haul)";
- **Three food headline behaviour goals**: "waste less food"; "eat more food that is locally in season" and "adopt a low impact diet";
- **One water headline behaviour goal**: "more responsible water usage"; and
- **One waste headline behaviour goal**: "increase recycling and segregation".

1.4 The 2008 report also gives an overview of the results of the work to segment the population by its propensity to adopt pro-environmental behaviours. The seven population segments identified were as follows[11]:

1. **Positive greens** (who have a high willingness and a high ability to act).
2. **Waste watchers** (a high ability to act, but medium willingness).
3. **Concerned consumers** (high willingness and ability, but slightly different profile to the positive greens).
4. **Sideline supporters** (high willingness, but low ability, to act).
5. **Cautious participants** (both a medium willingness and ability to act).
6. **Stalled starters** (both a low willingness and ability to act).
7. **Honestly disengaged** (low willingness to act, but medium ability).

1.5 Defra is taking forward its work on pro-environmental behaviours in a number of different ways, including commissioning further work. As part of this process, Defra commissioned AEA, together with the Policy Studies Institute and Metroeconomica, to undertake a project entitled *Household and economy wide impacts of changing environmental behaviours*. This project had three objectives:

- **Objective 1** – To assess the first order costs, benefits and CO_2 equivalent (CO_2e) abatement potential resulting from three different scenarios of uptake of the twelve headline behaviour goals listed above.
- **Objective 2** – To assess the feasibility of quantifying any indirect effect due to households spending any saved income on other goods and services (especially where these could have negative environmental impacts).
- **Objective 3** – To produce a conceptual note on how the impacts from Objectives 1 & 2 are likely to affect the wider economy, for example, pressure on infrastructure, effects on different economic sectors in the UK, balance of trade, etc.

[10] This headline behaviour goal is actually "use car less/Seek alternatives for journeys of 3 miles or less", but we have used only "use car less" in this report for ease of reference.

[11] See Table 2 of Defra (2008) and the Annex of the same report for more detailed profiles of the segments

1.6 The majority of the work focused on Objective 1, with progressively fewer resources being spent on the two subsequent objectives, reflecting the relative importance placed on the three objectives. The high level aim of Objective 1 was to identify an initial first order (order of magnitude) estimate of what the aspirational goals in the pro-environmental behaviours framework could potentially deliver in terms of CO_2e abatement. This estimate could only be an initial first order estimate for a number of reasons. First, this project was a first attempt at bringing together such information across a range of different behaviours. While the aim of the project was to collate a comprehensive set of data on the costs, benefits and potential CO_2e abatement potential of all the headline behaviour goals, it was recognised that this was likely to prove difficult and so the subsequent estimates that were likely to emerge from the project would only be partial. Second, as is evident from Objectives 2 and 3, neither second order (rebound) effects nor wider costs and benefits were considered within the project.

1.7 Throughout the project, the team was supported by members of the core Defra project team and the project Steering Group[12]. Additionally, comments from external reviewers and other government departments were taken on board in the drafting of the final report. The research began in January 2008.

1.8 In order to be consistent with Defra's previous work in this area, the scope of the project was England. The timescale considered was 2007 to 2020.

1.9 While every attempt has been made to ensure the quality and consistency of the data used, it is important to underline at this stage that the results presented in this report should be taken to be **indicative** for a number of reasons. These caveats are set out in Box 1-1 and are referred to, where relevant, throughout the report. It is difficult to assess the extent to which those caveats that might result in an overestimate are balanced by those that might result in an underestimation of the benefits. However, it is worth noting that the barriers to uptake that were not quantified (see point 6 of the list in Box 1-1) might be some of the most important factors preventing the adoption of a behaviour and hence, in such cases, it is more likely that the results are overestimates.

1.10 Additionally, it is important to note that the project relies on existing sources of data to derive its findings, so it did not generate new data on the costs, benefits and

[12] Here, and elsewhere in the report, 'Steering Group' refers to the Steering Group set up for the purpose of the project by Defra whose members were chosen for their relevant expertise from within both Defra and other government agencies. 'Experts associated with the Steering Group' refers to colleagues of Steering Group members who did not attend Steering Group meetings, but who were consulted in the course of the project for their more specific expertise.

Box 1-1: Caveats relevant to the results presented in this report

1. The scope and timescale of the project only facilitated the development of a relatively simple model that required a significant number of **high level assumptions**. For example:
    a. Some of the behaviours are relatively vague and the actions that might result are not explicit in Defra (2008). However, in order to undertake the project, it was necessary to identify such actions, although in many cases, it was not possible to identify a comprehensive set of actions. Consequently, a subset of the possible actions that could contribute to each of the behaviours was considered in the assessment, so the results are necessarily partial.
    b. It was not possible to identify a baseline consistent with the Energy White Paper for eight of the behaviours, as these were not covered by this document; hence, assumptions had to be made as to what the baseline for these actions might be.
2. **The illustrative uptake scenarios represent plausible levels of behavioural change.** These are based on expert judgement, informed by people's ability and indicated willingness to act, so should not be taken as predictions of the future.
3. The **cost estimates are based on 'typical' or 'average' households**; clearly the impacts for a particular household will vary according to its size, type, location and state of the dwelling. The impact of changes in behaviour will also depend on a household's existing profile with respect to the behaviour in question, e.g. its existing level of insulation or its travel patterns.
4. It was **not possible to identify a comprehensive set of quantified estimates for the non-CO_2e costs and benefits** associated with each of the behaviours. The estimates focused on direct financial costs and benefits to the households and did not, for example, include estimates of any health and environmental benefits or welfare losses attached to losses of service. Hence the estimates of costs and benefits associated with all of the behaviours are only partial. Consequently, the results potentially underestimate the benefits of some of the behaviours and overestimate the impact of others.
5. It was generally assumed that the **direct financial costs and benefits identified would not change over time**, whereas it is likely that these will change, particularly through technological development and economies of scale.
6. The **project made no attempt to quantify the barriers to uptake**. The uptake scenarios were restricted by a judgement of what could plausibly be overcome over time, although it is likely that these barriers will be significant, particularly for the *far reaching* scenario. However, it was not possible to estimate these. In practice, barriers to uptake might be the most important factor preventing take up.
7. **Some of the behaviours are closely linked**, so the potential benefits of one might influence the impact of another. While care was taken to take account of any subsequent overlaps, it is likely that some benefits have still been overstated. Conversely, the potential for the adoption of one of the behaviours to catalyse the uptake of others has not been captured within the scenarios.
8. The project has attempted to estimate first order costs and benefits only. Hence, **no attempt was made to quantify rebound effects**, as the consideration of indirect effects was outside of the scope of the project. Instead, the feasibility of modelling these was considered under Objective 2 (see Section 5).
9. Similarly, **no attempt was made to estimate any wider costs and benefits of behavioural change**, e.g. impacts on the wider economy. This was considered conceptually under Objective 3 (see Section 6).

abatement potential of the headline behaviour goals that it considered. In all cases, the most credible, reliable and respected sources were used; in particular work undertaken by or for UK governmental departments and agencies. In spite of this, it is important to recognise that information from a particular source will have been estimated or calculated for a particular reason, e.g. to inform policy development, and within a particular context and set of assumptions. Even though attempts were made to account for any such differences, the headline behaviour goals vary significantly in nature and therefore the way in which the data was estimated also varies. For example, a study to identify the costs, benefits and CO_2e abatement potential of installing domestic micro-generation is likely to require a completely different set of assumptions compared to a study estimating the same information for the adoption of a low impact diet. Consequently, while the results provide an indication of costs, benefits and CO_2e abatement potential, care should be taken not to give the results more authority than they deserve.

1.11 For these reasons, the results of the analysis presented below should **only be used in the context of this report**. We only present the detailed findings for the headline behaviour goals for which we have a higher level of confidence in the inputs and results. These headline behaviour goals are those for which extensive research has been undertaken to support government policy-making, i.e. three of the four energy headline behaviour goals: ***"install insulation"***; ***"buy energy efficient products"***; and ***"install domestic micro-generation"***. The results relating to these three headline behaviour goals are presented in Section 3. The results for the other nine headline behaviour goals are discussed in Section 0. It is worth noting, however, that for these other behaviours quantitative results are only presented in aggregate and that this aggregation covers only eight of these other nine behaviours. The omission is the ***"avoid unnecessary flights (short haul)"*** behaviour, as it was decided that it was not possible to determine in any meaningful way what this behaviour meant in practice, i.e. what an 'unnecessary' flight was. This issue is discussed in Section 0 (see, for example paragraph 4.11).

1.12 This document is the Final Report of the project and is set out as follows:

- **Section 2** gives an overview of the project method.
- **Section 3** discusses the approach taken, data used, results and the possible implications of missing costs and benefits for each of the three energy headline behaviour goals for which there was most confidence.
- **Section 4** discusses the same issues for the other nine headline behaviour goals, but presents the results in aggregate for the eight that were quantified.

- **Section 5** outlines a methodology to assess the feasibility of quantifying any indirect effect due to households spending any saved income on other goods and services (i.e. Objective 2 of the project).
- **Section 6** discusses how the impacts from Objectives 1 and 2 are likely to affect the wider economy (Objective 3).
- **Section 7** concludes the report.

2 Method

2.1 The broad approach to each of the following key elements of the method is discussed below (these contribute to Objective 1 unless stated):

- **Identifying actions** underlying each of the headline behaviour goals.
- The development of **three illustrative uptake scenarios** for each of the headline behaviour goals, in addition to the **baseline**.
- The **estimation of the costs, benefits and CO_2e abatement potential** associated with the headline behaviour goals.
- The **collation of data** to enable the estimation of costs, benefits and CO_2e abatement potential.
- The **development of a methodology** to quantify any indirect (rebound) effects due to households spending any saved income on other goods and services (Objective 2).
- The **production of a conceptual note** on how the impacts from Objectives 1 & 2 are likely to affect the wider economy (Objective 3).

Identifying the actions underlying each headline behaviour goal

2.2 As can be seen from the list of the twelve headline behaviour goals in Section 1, each is relatively general. In this form, it is not possible to identify associated costs, benefits and CO_2e abatement potential, as these will depend upon what specific actions are taken. For example, for the first headline behaviour goal, ***"install insulation"***, actions could include installing loft insulation, double glazing or cavity-wall insulation. It is therefore necessary to identify such actions before it is possible to identify the associated costs, benefits and CO_2e abatement potential. Consequently, the first stage of the project was to **identify appropriate actions for each of the twelve headline behaviour goals** in a way that permitted the identification of the necessary information to enable the subsequent analysis. The actions identified are given in the second column of Table 2-1.

2.3 In total 53 actions were identified, an average of nearly five per headline behaviour goal. It should be noted that the actions listed in Table 2-1 *are not meant to be a comprehensive or exhaustive list of actions that could contribute to the headline behaviour goal*. Given that the aim of Objective 1 was to estimate the costs, benefits and CO_2e abatement potential of adopting the headline behaviour goals, an important consideration in choosing the actions was the likely availability of the

necessary data. Consequently, the actions tend to be those that have either already received some policy attention or those that have been analysed in the academic or other literature.

2.4 In addition to only providing a partial coverage of the actions that might potentially contribute to each headline behavioural goal, it is also important to note that the selected actions *often interact and thus potentially reduce the abatement potential*. For example, if a person uses a car less and that car is a more efficient vehicle, the CO_2e reduction from this person's combined actions will be less than the total CO_2e reduction that would result if the actions were undertaken separately[13]. While the actions were defined so as to minimise such risks, aggregating the results for different headline behaviour goals is likely to over-estimate the CO_2e abatement potential.

Development of the illustrative uptake scenarios *and the baseline*

2.5 As was noted above, the aim of Objective 1 was to estimate the impacts of adopting the twelve headline behaviour goals under three different illustrative scenarios of uptake. The baseline and scenarios were defined as follows:

- The ***baseline*** represents **planned policies delivering as expected**. In order for the results to be as consistent as possible, the baseline included the planned policies, and associated emissions projections, as set out in the Energy White Paper (EWP)[14,15].
- The ***'limited response'*** scenario represents the case where planned policies (i.e. those policies set out in the EWP) do not deliver as expected.
- The ***'concerted'*** and ***'far reaching'*** scenarios are illustrative; they represent different levels of potential uptake of the actions that might result from the adoption of each of the headline behaviour goals. In this respect, they estimate the potential costs, benefits and CO_2e abatement associated with the adoption of the headline behaviour goals.

2.6 For each action, therefore, it was necessary to estimate the uptake under the

[13] The model that was designed to assess the impact of these actions (see below) was designed to allow Defra to vary the detail of the actions under consideration and even to add additional actions, as required (see Annex C for more details).

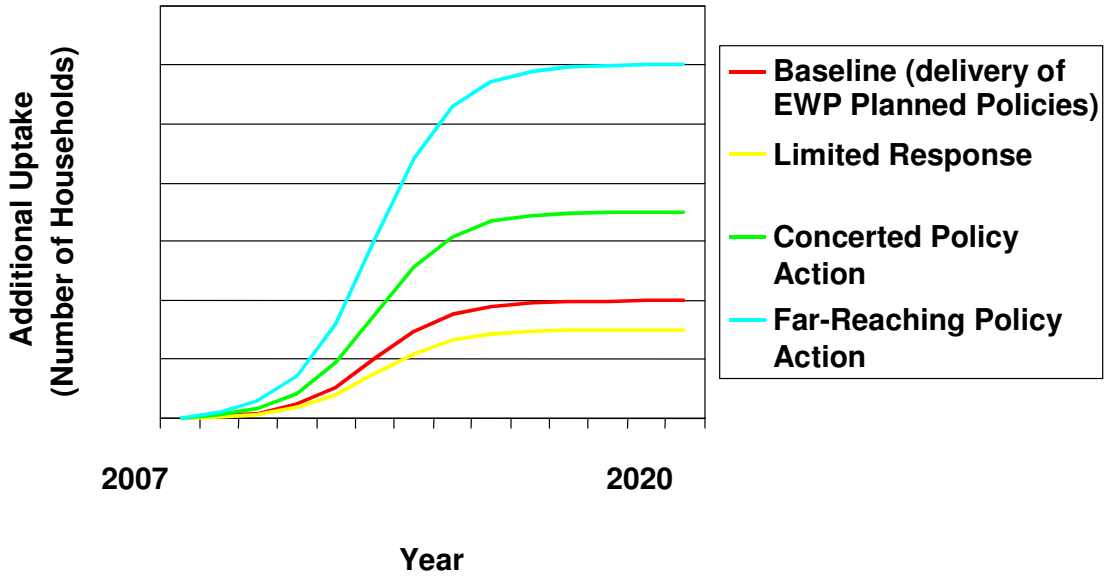
[14] *Meeting the Energy challenge: A White Paper on energy* Department of Trade and Industry, May 2007; see www.berr.gov.uk/energy/whitepaper/page39534.html; the emissions projections of relevance in this respect are known as UEP30 and can be found in *Updated energy and carbon emissions projections* Department for Business, Enterprise and Regulatory Reform, URN 07/947X (amended version of URN 07/947), February 2008; see http://www.berr.gov.uk/files/file39580.pdf

[15] We note that the baseline used in the EWP has subsequently been updated to reflect, for example, the new EU proposal that will require manufacturers to reduce CO_2 emissions from new cars. However, for the purpose of consistency within this project it was decided that the baseline to be used would be that used in the EWP.

baseline and each of the illustrative scenarios, as shown in Figure 2-1.

2.7 The first stage of the process was to review the available evidence to identify **existing levels of uptake**, i.e. the proportion of households that undertook each action in 2007, and the **maximum potential audience** for each action (see Table 2-1). In many cases, the latter is simply all households (i.e. 100%) – although in some cases this is less than 100% (e.g. those households that live in flats may not have a loft to insulate). The project team identified appropriate values for these figures from the available evidence and asked relevant experts in and associated with the Steering Group and more widely to confirm these or propose alternatives. For all of the actions, the **remaining available audience** was then calculated, which is simply the difference between the maximum potential audience and the existing uptake.

Figure 2-1: A visual representation of the illustrative scenarios to be identified



2.8 The next stage was to **develop the baseline** that was consistent with the EWP, i.e. to project the uptake of each action in 2020 without any additional policy intervention. For three of the four energy headline behaviour goals – i.e. those discussed in Section 3 – it was relatively easy to achieve such consistency, as the relevant policies are included in the EWP. As such, the baseline for each of these three headline behaviour goals was based on existing evidence, which was confirmed by the experts associated with the Steering Group. The policies included in the baseline for these headline behaviour goals were, therefore (see Annex B):

- ***"install insulation"***: Supplier obligation building on CERT.
- ***"buy energy efficient products"***: Supplier obligation building on CERT.
- ***"install domestic micro-generation"***: Existing promotional and support measures, as well as additional guidance, a more flexible market and licensing and easier access to distribution networks. Given subsequent policy developments, it is important to note that feed-in tariffs were not part of the baseline.

2.9 Initially, it was assumed that a similar approach could be taken for the ***"use more low energy consuming vehicles"*** behaviour, as there is a relevant policy instrument in the EWP, i.e. the successor to the ACEA, JAMA and KAMA voluntary agreements, which will increase the availability of low energy consuming cars for households to purchase. However, it was not possible to use the information in the EWP to identify a baseline for the chosen actions (i.e. those set out in Table 2-1) for this behaviour in the same way that it was for the three energy behaviours discussed above. Hence, the baseline for the ***"use more low energy consuming vehicles"*** behaviour was estimated by the project team and then agreed with the Steering Group[16].

2.10 For the remaining seven headline behaviour goals that for which relevant policies were not clearly included in the EWP, an alternative approach had to be developed. In such cases, experts in and associated with the Steering Group generally did not feel able to help to inform a baseline, as there were no agreed projections to suggest what the uptake of each of the actions might be in 2020. Consequently, it was decided that, unless there were reasonable grounds to assume otherwise, the baseline should assume that there is no additional uptake of the actions above 2007 levels before 2020. For example, if in 2007 15% of households undertook a certain action, then it was assumed that 15% would continue to undertake this action in every year until 2020 (see Figure 2-2)[17]. This approach was taken with five of these other seven headline behaviour goals.

2.11 The exceptions to the approaches illustrated in Figure 2-1 and Figure 2-2 were

[16] It was not considered appropriate to assume that the uptake of the actions under the ***"use more low energy consuming vehicles"*** behaviour under the baseline would be zero, as was done with some of the other behaviours (see paragraph 2.10), due to the existence of the policy instrument that would increase the availability of low energy consuming cars, as noted above.

[17] In such cases, while the proportion of households undertaking a particular behaviour remains constant, the number of households undertaking the behaviour is assumed to **increase**. This is due to the fact that the number of households in England is expected to grow. Hence, the same proportion of a larger number of households would be projected to undertake the action in future years.

in relation to the ***"increase recycling and segregation"*** and ***"better energy management in the home"*** behaviours. In both of these cases, there are government-funded bodies in place – WRAP and the Energy Saving Trust – whose role it is to encourage, respectively, recycling and energy efficiency in the home. Hence, in these cases, it was agreed that the baseline uptake should be half that of the *concerted* scenario (see below).

2.12 The next stage was to **develop the illustrative scenarios**. The ***limited response* scenario** was developed to be as consistent as possible with the policies in place prior to the introduction of the EWP. For those headline behaviour goals where the baseline had been defined using the EWP (i.e. three of the energy behaviours), achieving such consistency was relatively easy, as data was available. For these headline behaviour goals, the *limited response* scenario was informed ***by expert judgement*** (in the same way that the baseline was); the uptake under the *limited response* scenario for the ***"use more low energy consuming vehicles"*** behaviour was also informed by expert judgement, as noted in paragraph 2.9. For the other headline behaviour goals, the additional uptake under the *limited response* scenario was taken to be zero (as either there were no policies in place that might deliver or it was assumed that the activities of government-funded bodies did not result in a higher adoption of the actions associated with the ***"increase recycling and segregation"*** and ***"better energy management in the home"*** behaviours).

Figure 2-2: A visual representation of the Illustrative scenarios for the headline behaviour goals not covered by the EWP

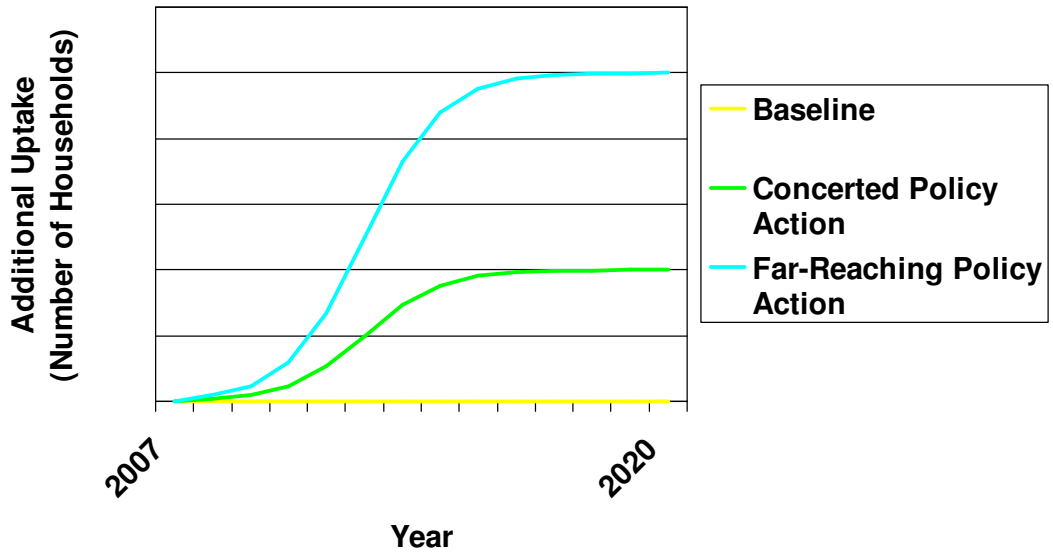


Table 2-1: Existing and additional uptake under the baseline and illustrative scenarios

Headline behaviour goal	Action	Situation in 2007†			Additional* households taking action by 2020††			
		Existing uptake (A)	Maximum potential audience (B)	Remaining available audience (B-A)	Limited response	Planned policies delivering the baseline	Concerted scenario	Far reaching scenario
Install Insulation	Loft Insulation (increasing thickness to 250mm)**	5%	78%[a]	73%	23%	50%	58%	66%
	Cavity wall insulation	31%	63%[a]	32%	16%	32%	32%	32%
	Solid wall insulation (internal)	2%	31%[a]	29%	0%	1%	2%	3%
	Solid wall insulation (external)	2%	31%[a]	29%	0%	1%	2%	3%
	Install higher standard (C) double-glazed windows	0%	98%[a]	98%	0%	4%	7%	13%
	Draught proofing	75%	100%	25%	7%	17%	20%	25%
	Floor insulation	18%	40%[a]	22%	0%	2%	3%	6%
Buy energy efficient products	Use low energy (compact fluorescent) light bulbs	20%	100%	80%	8%	56%	77%	80%
	Buy only highest rated wet appliances	48%	100%	52%	0%	52%	52%	52%
	Buy only highest rated cold appliances	0.3%	100%	99.7%	0.7%	46%	67%	88%
	Buy a laptop computer instead of a desktop computer & monitor	18%	100%	82%	27%	31%	57%	77%
Better energy management in the home	Switch off lights when not in room	26%	100%	74%	0%	11%	23%	69%
	No use of standby	19%	100%	81%	0%	4%	8%	71%
	Reduce heating by 1°C	14%	95%[b]	81%	0%	9%	19%	69%
	Use 30°C setting on washing machine	11%	100%	89%	0%	5%	11%	38%
Install domestic micro-generation	Solar photovoltaic	0.10%	31%[a]	31%	0%	0.4%	1%	3%
	Solar heating	3.40%	51%[a]	48%	0%	11%	17%	27%
	Wind turbine	0.1%	50%[a]	50%	0%	0.3%	1%	2%
	Gas CHP	0.0%	58%[a]	58%	0%	7%	15%	30%
Use more low energy consuming vehicles	Replace a petrol car with a diesel car	2%	40%[c]	39%	4%	15%	21%	25%
	Replace a petrol car with a hybrid car	0%	62%[c]	62%	1%	4%	8%	17%
	Replace a petrol car with an electric car	0%	15%[c]	15%	0.4%	1%	3%	10%
Use car less	Commuter lift-share	4%	33%[d]	30%	0%	0%	1%	6%
	Walk or cycle to work/school	9%	21%[d]	13%	0%	0%	1%	6%

	Walk for shopping	18%	38%[d]	20%	0%	0%	2%	10%
	Replace car ownership with car club membership	0.2%	10%	9.8%	0%	0%	2%	9%
Waste less food	Better understanding of best before/sell by dates	40%	100%	60%	0%	0%	12%	23%
	Better shopping practices (Plan meals for the week)	15%	100%	85%	0%	0%	6%	13%
	Cook correct amount of food	15%	100%	85%	0%	0%	6%	13%
Eat more food that is locally in season	Avoid air freighted produce	0%	100%	100%	0%	0%	15%	29%
	Avoid imported food where regional in season alternatives available	19%	100%	81%	0%	0%	15%	29%
	Grow own vegetables (allotment)	1%	100%	99%	0%	0%	0%	1%
Adopt a low impact diet* **	Buy no food grown in heated greenhouses	0%	100%	100%	0%	0%	19%	36%
	Eat no more than 3 portions of meat per week	20%	100%	80%	0%	0%	8%	16%
	Adopt a vegetarian diet	3%	100%	97%	0%	0%	1%	3%
	Adopt a vegan diet	2%	100%	98%	0%	0%	1%	2%
More responsible water usage	Turn tap off when brushing teeth	52%	100%	48%	0%	0%	22%	43%
	Replace a regular bath with a shower	52%	100%	48%	0%	0%	22%	43%
	Use dishwasher only when full	37%	100%	63%	0%	0%	10%	20%
	Insert 'hippo' water saving device in the toilet	37%	100%	63%	0%	0%	10%	20%
	Fix dripping taps promptly	37%	100%	63%	0%	0%	10%	20%
	Install a spray head on taps	7%	100%	93%	0%	0%	6%	12%
	Install a dual flush toilet	7%	100%	93%	0%	0%	6%	12%
	Use a watering can instead of a hose/sprinkler	52%	89%[e]	37%	0%	0%	17%	34%
	Install a water butt in the garden	37%	89%[e]	52%	0%	0%	9%	17%
Increase recycling and segregation** **	Metal packaging	16%	100%	84%	0%	16%	32%	74%
	Glass bottles & jars	49%	100%	51%	0%	14%	28%	41%
	Paper	43%	100%	57%	0%	8%	17%	47%
	Card	29%	100%	71%	0%	16%	31%	61%
	Food waste	8%	100%	92%	0%	9%	17%	82%
	Garden waste	53%	100%	47%	0%	12%	24%	37%
	Dense plastic	25%	100%	75%	0%	17%	35%	65%
	WEEE (Drive to HWRC)	62%	100%	38%	0%	17%	34%	34%

† The information presented in relation to the situation in 2007 was based on existing evidence and was confirmed by experts associated with the Steering Group.
†† The percentages presented for additional households adopting the actions by 2020 were generally based on expert judgement of how to apply survey data. The exceptions to this were the four headline behaviour goals that were explicitly included in the EWP, i.e. ***"install insulation"***; ***"buy energy efficient products";***

and ***"install domestic micro-generation"***, where the figures for the respective baselines and *limited response* scenarios were taken from the research supporting the EWP.

* The percentages in the final four columns represent the number of ***additional*** households taking up the behaviour. For example, the number of *additional* households taking up the loft insulation action under the *far reaching* scenario is 66%, which means that under this scenario 71% (i.e. 5% (A) + 66%) of households will have adopted this action by 2020.

** The loft insulation behaviour is concerned with increasing the thickness of loft insulation. Currently many houses have loft insulation with a thickness of around 100mm, but only 5% of households have insulated their lofts to a thickness of 250mm.

*** An action that was initially considered under the ***"adopt a low impact diet"*** behaviour was to adopt a mostly organic diet. However, it was not possible to identify with any confidence whether the adoption of an organic diet had any benefits in terms of its potential to reduce greenhouse gas emissions.

**** Note, the recycling uptake figures are based on capture rates, and therefore assume that those who recycle fully participate (i.e. fully recognise material)

[a] Limited by the technical characteristics of the household required

[b] For some households, it is not possible to reduce their temperatures, as they already do not an adequate level of heating for a range of reasons, including cost. Note that the World Health Organisation recommends 21 degrees in the daytime and 18 degrees in the bedroom.

[c] Takes into account that i) not all households own car (around 80% do) and ii) limits on suitability of type of car.

[d] Limitations due to specific journey requirements, safety, distance and availability of service.

[e] Limited by the number of households with a garden.

2.13 It was then necessary to develop the **illustrative *concerted* and *far reaching* scenarios**. The uptake for each of the actions that might be adopted for each of the headline behaviour goals was ***based on expert judgement*** and informed by the large amount of information present in the Defra survey of attitudes, knowledge and behaviour in relation to the environment[18]. However, this information was used with some caution and was cross-checked with other sources. In order to reduce potential bias, all assumptions and judgements were tested internally within the project team, and then shared and agreed with Defra (see Annex A for more detail). Note that, as a result of the approach taken, ***no additional policy assumptions*** were associated with these scenarios beyond those that were considered to be part of the baseline (see paragraph 2.8).

2.14 It is important to note that the results of Defra's survey provide ***a view of individuals' attitudes, knowledge and behaviour*** in England, split by population segment, whereas the project was assessing the potential costs, benefits and abatement potential of ***household behavioural change***. In this project, therefore, it was necessary to assume that the individuals surveyed represent their entire household, so that all the members of the household will adopt the relevant actions.

2.15 The projected uptake rates for the planned policies (delivering the baseline) and illustrative scenarios in 2020 for each of the actions associated with achieving each of the headline behaviour goals are presented in Table 2-1. It is important to note that these ***uptake rates are illustrative***, so they are not necessarily compatible with other government objectives, as they might have wider social, economic and environmental impacts. These wider impacts – both positive and negative – are discussed in the following sections.

2.16 As noted in paragraph 1.11, a quantitative assessment was not undertaken for the ***"avoid unnecessary flights (short haul)"*** behaviour. Hence, this behaviour is not included in Table 2-1 (see paragraph 4.11 for a further discussion).

2.17 For those behaviours for which an uptake rate was projected, it was assumed that uptake from 2007 to 2020 followed a standard S-curve trajectory in response to future behavioural change policies (see Figure 2-1). This trajectory was assumed because the characteristics of behavioural change are such that people will often take some time to consider the merits of an action and tackle the various barriers to

[18] Defra (2008) *A Framework for Pro-environmental behaviours* January 2008; see http://www.defra.gov.uk/evidence/social/behaviour/index.htm

adoption, such as the need to change habits.

2.18 It is important to note that the baselines and illustrative scenarios developed for the project are the result of a high level process across a very wide range of behaviours. This was important in order to ensure that, as far as possible, a consistent approach was taken across the very different headline behaviour goals. The scenarios, therefore, illustrate an assessment of future uptake intended only for the purposes of this project. It would be important to undertake a more detailed assessment of specific measures in advance of any specific policy action.

Estimation of costs, benefits and CO_2e abatement potential

2.19 The model that was developed as part of the project (see Annex C for more detail on this) was set up to estimate the costs, benefits and CO_2e abatement potential of each of the eleven headline behaviour goals for which a quantitative assessment was undertaken and to enable the cost effectiveness of the behaviours to be assessed. The **cost effectiveness assessment (CEA)** of each of the three behaviour goals for which results are presented in detail is estimated by comparing the net costs (or benefits) per tonne of abated CO_2e. In the context of this project, therefore, a CEA enables the comparison of the cumulative costs (and benefits) of achieving different rates of uptake by 2020 (as determined by the different scenarios) of the different headline behaviour goals and enables these to be compared by means of a common objective, i.e. reducing CO_2e emissions. As the cost effectiveness is calculated by subtracting benefits from costs, a negative value suggests that the behaviour/scenario combination is ***relatively cost-effective***, while a positive value suggests that the result is ***relatively cost-ineffective***. Government guidance states that an intervention is deemed to be cost-effective if this CEA figure is below the Government's projection for EU ETS allowances (in the case of traded sector emissions savings), or below projections for the Shadow Price of Carbon (in the case of non-traded sector emissions savings).

2.20 The approach that was taken with respect to the estimation of costs and benefits is in line with guidance provided by Defra, including the need to ensure consistency, as far as was possible, with other ongoing cost effectiveness analysis, and was supplemented by the relevant guidance from the Department for Transport and the Treasury[19]. More details on the approach method used for the estimation of

[19] For example, the Treasury's *Green Book, Appraisal and Evaluation in Central Government'*; see greenbook.treasury.gov.uk; DfT's webtag, see www.webtag.org.uk

costs and benefits and on the cost conventions employed in the various assessments can be found in Annex D.

Collation of data on costs, benefits and CO_2e abatement potential

2.21 In the course of the project, an attempt was made to identify and quantify the following costs and benefits for the eleven behaviours, where relevant and possible:

- Costs:
  - Capital (fixed);
  - Operational costs (variable);
  - Maintenance (variable);
  - Administration (including policy costs);
  - Environmental and social costs; and
  - Hidden costs (e.g. time and space).
- Benefits:
  - Operational savings for consumer;
  - Environmental benefits (including CO_2e savings, improvements to air quality, noise, biodiversity, etc);
  - Residual value; and
  - Social benefits (e.g. health).

2.22 The financial data on the capital costs, operational costs and savings, any residual value and CO_2e abatement potential associated with adopting the actions under the headline behaviour goals were taken from respected sources, often work undertaken for or by government departments or agencies, or other bodies involved in the regulatory system, e.g. regulators. Confidence in the data is strongest for the actions under the three energy headline behaviour goals (discussed in Section 3) and weaker for others (presented in Section 0). For many of the headline behaviour goals, estimates and assumptions had to be made, but we believe that these are sensible (see Annex E for more details).

2.23 Information on the environmental and social costs and benefits of the actions under each of the headline behaviour goals, other than the associated CO_2e emissions, was not easy to identify. Indeed, it was only possible to identify these for a few actions, e.g. the benefits associated with reduced noise and air emissions resulting from less overseas transport under the ***"eat more food that is locally in season"*** behaviour and the potential health benefits of the ***"adopt a low impact diet"*** behaviour. As a result, it was decided by the Steering Group that the results should be presented **without the inclusion of environmental and social costs and benefits**.

2.24 An attempt was made to value time and space where it was felt that it was

sensible to do so and where it was possible to obtain estimates or make sensible assumptions. For example, the cost of space has been assessed in relation to the use of household space for recycling boxes and internal wall insulation and garden space for water butts. It was agreed with the Steering Group that time should not be valued where relevant actions were anticipated to take less than five minutes. For example, the time associated with switching off a light switch was not included. For other actions, it was not possible to identify a suitable 'average' time saved that could be sensibly used within the project.

2.25 In order to ensure that policy costs were included in the analysis, the project team reviewed available information for examples of past policy costs. This exercise proved difficult, as these costs are not widely available, even within existing impact assessments. As a result, following consultation with Defra, the same indicative policy costs were assumed for all of the headline behaviour goals in order to reflect the relative policy investment required to move from the baseline to the *concerted* or the *far reaching* scenario. In the case of the *limited response* scenario, policy costs were taken to be zero (as the policies have already been planned), while policy costs of £60 million and £360 million were associated with the *concerted* and *far reaching* scenarios, respectively (see Annex D for more detail).

2.26 In summary, therefore all of the costs and benefits listed in paragraph 2.21 were included in the cost assessments undertaken in this project apart from environmental and social costs and benefits; values of time; and the costs of overcoming any barriers or loss of welfare.

2.27 It is important to note that, given the objective of this work, the costs and benefits discussed in the following sections are 'average' or 'typical' values. In each case, these are determined from the available data. For this analysis, this is the most appropriate approach to take. However, it is important to note that, for a particular household, the costs and benefits that would be experienced in reality are variable, as these will depend upon *inter alia* the size, type, state and location of the dwelling.

2.28 Given that it was not possible to quantify all the first order costs and benefits resulting from changing the behaviours, the assessment presented below is necessarily a partial assessment. This is generally the case with most economic assessments, as it is very difficult to quantify all costs and benefits in any one assessment. Within the existing project, given that it relied on existing sources of information and that a comparison was being undertaken across distinctively

different headline behaviour goals, it was even more difficult to identify costs and benefits other than purely financial costs and benefits. Hence, it was decided that these costs and benefits should be excluded in order to enable the results to be presented in as consistent and comparable fashion as possible. The potential impacts of including the missing costs and benefits are discussed qualitatively in the sections that follow, where appropriate.

2.29 Finally, it is important to note that the results presented in the next two sections take no account of second order (rebound) effects, e.g. any potential adverse impact resulting from householders spending the money saved from adopting a pro-environmental behaviour on other goods and services, or of any impacts on the wider economy, e.g. pressure on infrastructure. As noted in Section 1, the estimation of these costs and benefits was outside the scope of the project. However, the feasibility of quantifying rebound effects and a conceptual note on wider impacts are presented in Sections 5 and 6, respectively.

Methodology underlying Objectives 2 and 3

2.30 Objective 2 involved a review of the relevant background literature to identify potential methods for estimating second order (rebound) effects, supplemented by expert discussion (see Section 5 and Annex F). The work under Objective 3 involved an initial scoping of types of wider impact, followed by an assessment of possible approaches for quantifying wider effects on the economy (see Section 6). Both were subsequently presented to, and discussed, by the Steering Group.

3 Overview and discussion of results for the main energy headline behaviour goals

3.1 The aim of this section is to present, for the three energy headline behaviour goals for which there is most confidence, the findings of the analysis undertaken using the model developed as part of this project. The findings for each of the three behaviours – ***"install insulation"***; ***"buy energy efficient products"***; and ***"install domestic micro-generation"*** – are presented in turn, before being compared in the concluding section. Within the sub-section on each of the headline behaviour goals, the follow elements are discussed:

- Approach taken to the estimation of the potential CO_2e abatement and associated costs, along with any issues that arose.
- Results of the analysis, including:
  - Potential CO_2e abatement in England by illustrative scenario;
  - Potential, maximum financial savings per household; and
  - Cost effectiveness by illustrative scenario.
- Potential implications of missing information on costs and benefits, i.e. how the monetisation of these missing elements might affect the results of the economic assessment.

3.2 A more detailed overview of the sources used and others reviewed can be found in Annex E.

3.3 As noted in Box 1-1, for all of the headline behaviour goals assessed in this project, it was not possible to identify a comprehensive set of quantified estimates of costs and benefits. Consequently, the results of the assessment presented below are based only on an assessment of the **first order financial costs and benefits to the household**. For each of the headline behaviour goals, the potential implications of including the unquantified costs and benefits are discussed in the section following the presentation of the respective results of the assessment. Additionally, it is important to recall at this stage that rebound effects and wider costs and benefits were not included in the assessment (see, respectively Sections 5 and 6 for a further discussion of how these elements might be included in a wider, future assessment).

Install insulation

Approach and issues

3.4 Identifying the actions and data for the ***"install insulation"*** behaviour was relatively easy, as there has been a fair amount of UK policy in the area. Data on the estimated costs and abatement potential from a range of insulation actions are available from the work undertaken in support of the Carbon Emission Reduction Target (CERT). These data represent the most up to date information on these actions, as they have been used to inform Government policy and are based on information provided by energy suppliers, representatives of the industries concerned and by experts, including the Energy Saving Trust (EST) and the Building Research Establishment (BRE).

3.5 The actions chosen to represent the ***"install insulation"*** behaviour were, therefore, generally a selection of those for which CERT (2008) data was available. The one exception was the 'floor insulation' action for which information from CERT was not available; instead data from BRE (2007) was used. While these actions are not necessarily all the actions that a householder could apply in the context of the ***"install insulation"*** behaviour, they are the ones being most promoted under CERT and are therefore most likely to be widely adopted in the period under consideration.

3.6 As it has been used to inform policy decisions, the CERT/BRE data was the most robust available. The data included the following financial costs and benefits that were used in the estimation of abatement potential and cost effectiveness:

- Capital cost.
- Annual maintenance cost.
- Annual energy savings.

3.7 Additionally, the impacts of the change in household space required for the installation of some insulation actions, e.g. internal wall insulation, were estimated, but the inclusion of this small negative effect was not enough to outweigh the benefits.

3.8 As noted in paragraph 2.8, the baseline for all of the energy headline behaviour goals discussed in this section was taken to include the relevant policies outlined in the EWP, which, in the case of installing insulation, is the supplier

obligation based on CERT[20]. In line with the respective definition, the *limited response* scenario was taken to be where the planned policies – i.e. the supplier obligation based on CERT – did not deliver as expected.

3.9 It was also assumed that each household adopting one of the actions, i.e. installing the specified insulation, was subject to the same financial costs and benefited from the same level of energy savings, as other households.

3.10 As noted above, the uptake scenarios are based on expert judgement and represent plausible levels of behavioural change, as they are based on people's ability and indicated willingness to act. Typically for insulation actions, judgements on future uptake have been made in the context of existing rates of uptake by population segment and an understanding of the characteristics of the action. For example, floor insulation is generally considered to be a very disruptive process which would require a targeted intervention that would only be seen under *concerted* and *far reaching* scenarios, perhaps obliging cost effective applications at the point of change of occupancy.

Results of the assessment

3.11 As can be seen in Figure 3-1 (see Box 3-1), under the illustrative *concerted* scenario there is the potential to deliver around 10 $MtCO_2e$ of additional abatement between 2007 and 2020 in England, with further emissions savings of nearly 25 $MtCO_2e$ potentially delivered by the *far reaching* scenario. This would be in addition to the policies planned in the EWP that could deliver over 40 $MtCO_2e$ of abatement in the same period[21]. As noted in Figure 3-1, all of this potential CO_2e emissions abatement would take place in the non-traded sector[22]. Figure 3-3 (in Box 3-4) shows that these emissions reductions would be cost-effective. The comparatively high results for the planned policies are driven by the cost savings associated with installing cavity wall insulation, which has a high uptake under the baseline (see Table 2-1).

3.12 Figure 3-2 (see Box 3-3) suggests that the financial benefits per household of installing insulation are potentially significant, i.e. nearly £160 a year. This assumes that a household is currently not taking any of the actions considered (i.e. those listed

[20] http://www.defra.gov.uk/environment/climatechange/uk/household/supplier/cert.htm

[21] This figure is equivalent to an annual saving of around 0.8 millions tonnes of carbon (MtC), which is within the 3 to 4 MtC annual savings that the Government expects a supplier obligation to deliver; see paragraph 2.46 of the EWP at http://www.berr.gov.uk/files/file39566.pdf

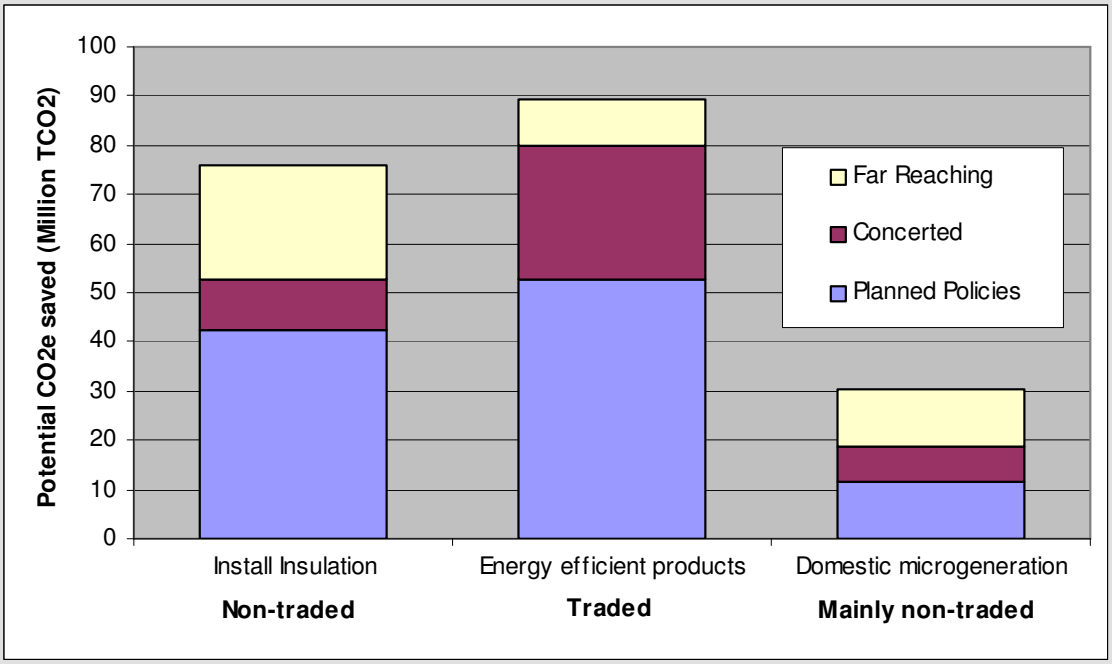
[22] This assumes that all of the energy savings resulting from installing insulation arise from the need to use less gas for domestic heating.

in Table 2-1).

Box 3-1: Total cumulative CO_2e abatement potential (from 2007 to 2020) by headline behaviour goal broken down by illustrative scenario

Figure 3-1 displays the total cumulative CO_2e abatement potential by illustrative scenario for each of the energy headline behaviour goals discussed in Section 3. The CO_2e abatement potential of planned policies arises from the emissions reductions that the Government policies set out in the EWP should deliver. The potential abatement indicated for the *concerted* scenario represents the ***additional*** emissions reductions (over and above that achieved by planned policies) that could be achieved if the uptake levels presented in Table 2-1 were achieved for the respective scenario. Similarly, the abatement potential indicated for the *far reaching* scenario represents the ***additional*** emissions reductions compared to those achieved by planned policies **and** the *concerted* scenario.

Figure 3-1: Total cumulative (from 2007 to 2020) CO_2e abatement potential by headline behaviour goal broken down by illustrative scenario



Potential implications of missing information on costs and benefits

3.13 As can be seen from the qualitative assessment of other potential costs and benefits (see Box 3-2), there are significant benefits that have not been quantified for the ***"install insulation"*** behaviour; these relate to the benefits in noise reduction associated with the installation of double glazing and the potential subsequent benefits to health and comfort of warmer homes. These benefits may be considerable (particularly the health benefits for certain age groups) and their quantification and inclusion in the economic assessment would make the behaviour even more cost-effective. There may also be some negative impacts, specifically for historic homes when considering actions that might be visible, e.g. solid wall insulation.

Box 3-2: Qualitative assessment of energy behaviours

As noted above, it was only possible to assess quantitatively the financial costs and benefits associated with the energy behaviours discussed in this section. In the table below, the wider environmental, social and other impacts are assessed qualitatively to indicate how their respective inclusion in the cost assessment may have influenced the results of the cost effectiveness assessment.

Table 3-1: Qualitative assessment of the potential inclusion of the missing costs and benefits in the assessment of the cost effectiveness of the three energy behaviours

	Impact	Install Insulation	Energy Efficient Products	Install Domestic Micro-generation
Environment	Noise	✔ ✔	–	✕
	Local Air Quality	–	–	✕
	Odours	–	–	✕
	Landscape	–	–	✕
	Townscape	–	–	✕
	Heritage of Historic Resources	✕	–	✕
	Biodiversity	–	–	–
	Water resources	–	✔	–
Health and Safety	Physical Fitness	–	–	–
	Safety	–	–	–
	Security	–	–	–
	Impacts on disadvantaged groups	✔	✔	–
	Health	✔ ✔	–	–
Barriers	Time	–	–	–
	'Hassle'	✕	–	✕
	Comfort / Service	✔ ✔	–	–

3.14 It is also worth noting that any action that results in reduced energy bills would

have particular benefits for lower income and other disadvantaged groups.

Summary

3.15 The data used for the assessment of the ***"install insulation"*** behaviour are reasonably robust, as they have already been used in policy assessment. Hence, there is a relatively high degree of confidence in the data sources. The discussion above has illustrated that, whilst there are gaps within the quantitative analysis, the impact of these is likely to be largely positive on balance and therefore the results of the cost effectiveness assessment is likely to be on the conservative side. The additional potential CO_2e abatement between 2007 and 2020 in England under the illustrative *concerted* and *far reaching* scenarios is nearly 10 $MtCO_2e$ and around 25 $MtCO_2e$ emissions, respectively, all of which would occur in the non-traded sector.

Buy energy efficient products

Approach and issues

3.16 The actions identified for the ***"buy energy efficient products"*** behaviour were also relatively easy to identify, as there has been a lot of European and UK policy to improve the energy efficiency of energy consuming products and the UK has instigated a Market Transformation Programme (MTP) to help stimulate the introduction of such products. Analysis has also been undertaken on the costs and abatement potential of energy efficient products under CERT. Hence, the actions, abatement potential and costs were taken from MTP (2007; 2008) and CERT (2008). Data from MTP were used to estimate the marginal costs of the full range of these appliances, as these were based on a wider range of products. The costs included in the cost effectiveness assessment included:

- Capital cost.
- Annual maintenance cost.
- Annual energy savings.

3.17 As with the ***"install insulation"*** behaviour, while the chosen actions are not necessarily all the actions that a householder could apply in the context of the ***"buy energy efficient products"*** behaviour, those actions included are the ones that have the greatest potential to deliver the greatest levels of CO_2e savings under CERT and/or significant levels under MTP.

3.18 Similarly, the policies included in the baseline for the ***"buy energy efficient products"*** behaviour were those outlined in the EWP, i.e. the supplier obligation

based on CERT, and the *limited response* scenario was taken to be where this policy did not deliver as expected.

3.19 For all the actions under the ***"buy energy efficient products"*** behaviour, it was assumed that the householder only replaces appliances at the end of their life, rather than proactively buying energy efficient models to replace appliances that are still working. This means that the marginal cost of an energy efficient product was considered in the assessment, i.e. the price premium above and beyond the cost of a non-energy efficient product. The second implication of the end-of-life assumption is that there are no installation costs – because the cost is assumed to be the same regardless of whether an energy efficient or non-efficient appliance is installed.

3.20 The illustrative uptake scenarios were based on expert judgement and interpretations of people's willingness to act indicated in response to the relevant survey questions.

Results of the assessment

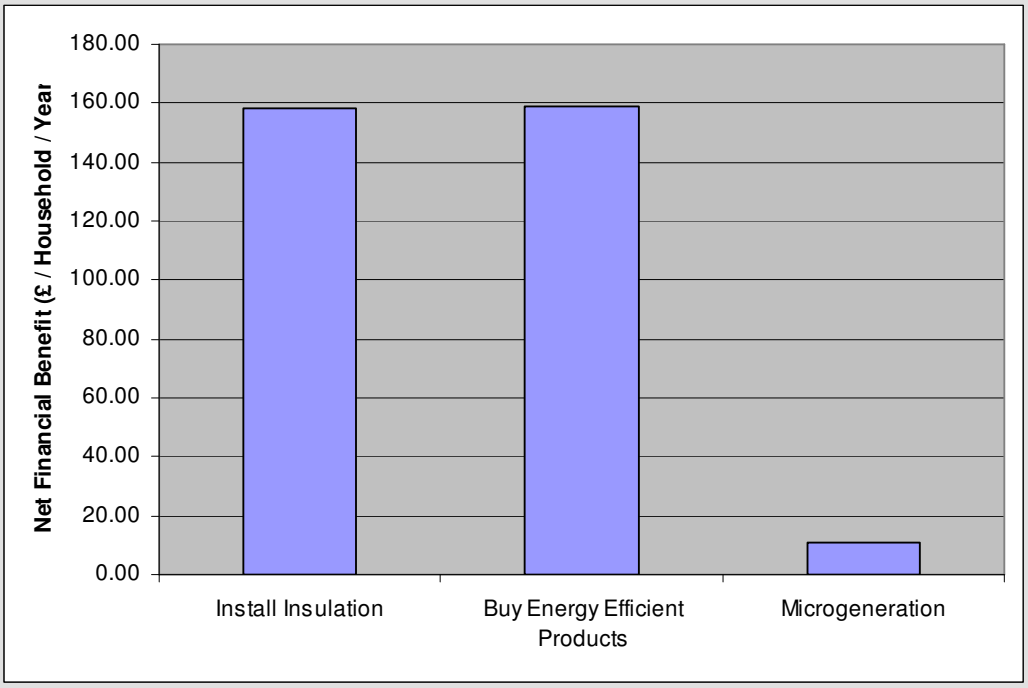
3.21 If the ***"buy energy efficient products"*** behaviour was adopted at the rates assumed under the illustrative *concerted* scenario, around 30 $MtCO_2e$ could be abated additionally between 2007 and 2020. Further savings of nearly 10 $MtCO_2e$ could be delivered under the *far reaching* scenario (see Figure 3-1 in Box 3-1). This is additional to the 50 $MtCO_2e$ that could be delivered between 2007 and 2020 if planned policies deliver as anticipated. All of these emissions reductions would occur in the traded sector, as the CO_2e savings are due to lower electricity use. As can be seen in Figure 3-3 (in Box 3-4), these savings could be considered to be cost-effective. It is worth noting that the *additional* CO_2e to be saved under the *concerted* and *far reaching* scenarios is lower than the reductions achieved by planned policies. This is due to the relatively extensive policy decisions that have already been taken in this area, which have been captured within the baseline (see Table 2-1). This leaves comparatively fewer households to take up the action under the additional illustrative scenarios.

3.22 As with the previous headline behaviour goal, the financial benefits per household of buying only energy efficient products are potentially significant (see Figure 3-2 in Box 3-3) at nearly £160 a year. However, again it is important to note that this is an average figure and also assumes that a household has not adopted any of the relevant actions (i.e. those listed in Table 2-1).

Box 3-3: Financial savings per household by headline behaviour goal

Each of the headline behaviour goals modelled is likely to incur financial costs and benefits to the households that implement them. However, the actual costs and benefits will vary by household, depending upon *inter alia* the house type, its current energy usage and other factors. Figure 3-2 shows the ***maximum potential annual financial benefit*** for an ***average*** household if it were to ***take up all the possible actions*** for each of the respective headline behaviour goals. Only 'possible actions' are considered, as account is taken of the fact that some of the actions are mutually exclusive, e.g. a household would not install interior and exterior wall insulation[23].The capital costs of all goods purchased have been annualised and added to any annual operating costs that may be incurred to estimate the costs. The benefits have been estimated by assessing the financial savings the household may experience, primarily from reduced energy costs.

Figure 3-2: Average, maximum potential net annual financial benefits for households of taking up each energy headline behaviour goal



Potential implications of missing information on costs and benefits

3.23 As can be seen from the table in Box 3-2, there are few other direct impacts

[23] In estimating cost-effectiveness and potential total CO_2e abatement, such issues are accounted for by limiting the potential uptake under the scenarios.

associated with buying energy efficient products. Those that have not been quantified are generally beneficial and so would further improve the cost effectiveness of the headline behaviour goal. For example, energy efficient 'wet' household appliances tend to be more water efficient than less energy efficient appliances, so this action would have a beneficial impact on water resources. As with the other energy headline behaviour goals, any action that results in reduced energy bills would have benefits for lower income and other disadvantaged groups.

Summary

3.24 As with the ***"install insulation"*** behaviour, the data used for the assessment of the costs of the ***"buy energy efficient products"*** behaviour are reasonably robust, as most of it has already been used in policy assessment. Similarly, the impact of quantifying the missing impacts would be positive, so the assessment of cost effectiveness is likely to be on the conservative side. There is the potential to deliver around an additional 30 $MtCO_2e$ savings in England if the actions under the behaviour were adopted at the rates indicated under the illustrative *concerted* scenario, with further savings of nearly 10 $MtCO_2e$ being potentially delivered under the *far reaching* scenario. All of these savings would be in the traded sector.

Install domestic micro-generation

Approach and issues

3.25 As with the actions assessed under the other energy headline behaviour goals discussed in this section, CERT (2008) was used as the main source of data for the ***"install domestic micro-generation"*** behaviour. As before, the CERT data was seen as the most robust available as these had been used to inform policy decisions. The use of the CERT data in this way had the additional advantage that the data used for the headline behaviour goals presented in this section are all comparable as they would have been produced using the same methodology. The costs taken from CERT were:

- Capital cost.
- Annual maintenance cost.
- Annual energy savings.

3.26 However, in addition to the CERT data a DTI/EST (2005) study was used to determine the potential future change in the cost of each type of micro-generation action by the year 2020. This was included as the relevant technologies are in their relative infancy – the DTI/EST study used learning curve analysis to determine the

potential cost reduction in 2020.

3.27 The actions chosen to represent the ***"install domestic micro-generation"*** behaviour were, therefore, generally those for which CERT (2008) data was available. As with the other two headline behaviour goals discussed above, while the chosen actions are not necessarily all the different ways of installing domestic micro-generation, they are the ones that are most likely to be widely introduced prior to 2020.

3.28 In the case where households adopted the behaviour, i.e. installed one of the domestic micro-generation actions, it was assumed that they all faced the same capital costs and received the same benefits in terms of energy savings. In reality, of course, the costs and benefits to different households will vary depending on a range of factors (see below).

3.29 Under the baseline, it was assumed that the policies to encourage micro-generation that were set out in the EWP, i.e. additional guidance, a more flexible market and licensing and easier access to distribution networks, achieve their aims, while under the *limited response* scenario, it was assumed that these do not. The illustrative uptake scenarios represent plausible levels of behavioural change. The solar photovoltaic and wind turbine uptake scenarios were based on expert judgement[24] of people's responses to relevant survey questions. The solar heating and gas CHP uptake scenarios are informed by information provided by the Steering Group.

Results of assessment

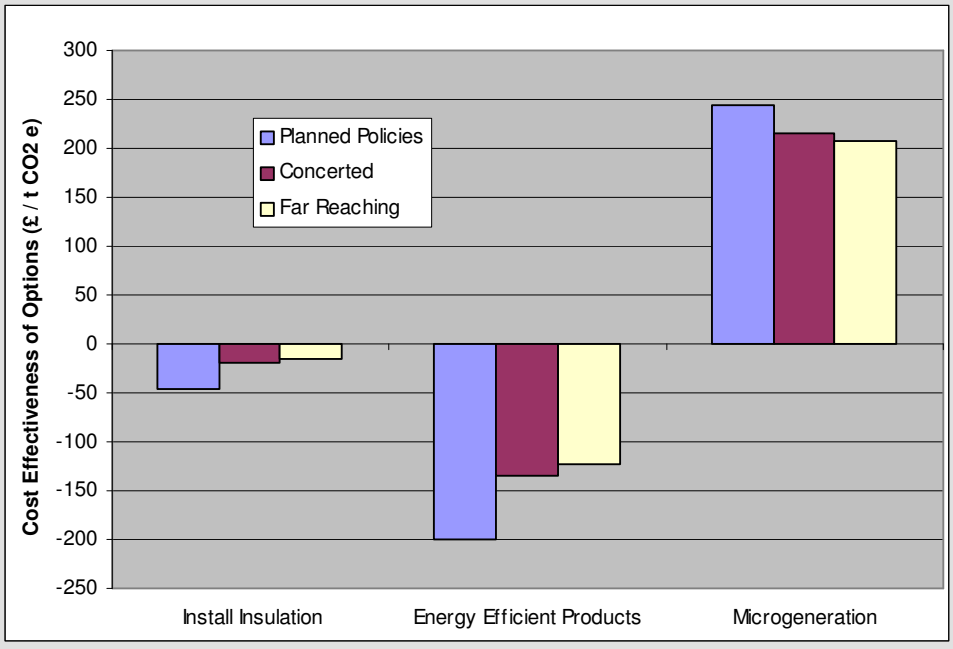
3.30 As can be seen from Figure 3-1 (Box 3-1), the installation of domestic micro-generation has the potential to save between 5 and 10 $MtCO_2e$ between 2007 and 2020 under the *concerted* scenario, while more than 10 $MtCO_2e$ could be delivered under the *far reaching* scenario. The emissions reductions that result from installing micro-generation would mainly occur in the non-traded sector, as most of the CO_2e saved would be from reduced gas used in heating. Figure 3-3 shows that these savings are *currently* cost ineffective when it comes to reducing CO_2e principally due to the high capital costs for the technologies included. It is worth noting that since the research for this project was completed, BERR has produced a more up-to-date

[24] The relevant survey questions took the format 'Have you installed or are you seriously considering instilling ....'. The results generally suggest a rather high willingness to install. These results are taken to be the case for the *far reaching* scenario where the incentive and enabling policies would likely tackle many of the barriers to adoption. This willingness is halved for the concerted scenario.

Box 3-4: Cost-effectiveness by energy headline behaviour goal and illustrative scenario

Figure 3-3 displays the cost effectiveness of each of the three energy headline behaviour goals for the planned policies (delivering the baseline) and each of the illustrative scenarios. As discussed in paragraph 2.19, the abatement potential of a headline behaviour goal could be considered to be cost-effective under a certain scenario if its cost effectiveness is less than projections of EU ETS allowance prices (£31.62/tonne CO_2e in 2020, in 2008 prices) if the savings are in the traded sector, or less than the Shadow Price of Carbon (i.e. £33.60/tonne CO_2e in 2020, in 2008 prices) if the savings are in the non-traded sector. The more negative its cost-effectiveness, the more relatively cost-effective the behaviour is in terms of reducing CO_2e emissions. On the other hand, a high, positive cost effectiveness represents relative cost-ineffectiveness. The cost effectiveness of the headline behaviour goals for the baseline are those associated with the ***delivery of planned policies***; whereas the cost-effectiveness of the headline behaviour goals under the *concerted* and *far reaching* scenarios are those associated with the illustrative uptakes under the respective scenarios ***compared to the planned policies***. It is important to recall that the assessment presented below is necessarily partial for all the reasons stated elsewhere.

Figure 3-3: Cost effectiveness of the energy headline behaviour goals



report on the potential for micro-generation on which could increase the potential

CO_2e savings from installing micro-generation[25]. In 2009, other policies have been announced, such as in DECC's *The UK Low Carbon Transition Plan*[26], that will stimulate micro-generation through feed-in tariffs, which were not included in the policy baseline assumed within this project, as this was based on the policies in EWP 2007 (see paragraph 2.8).

3.31 Given that the payback period for the "install domestic micro-generation" behaviour is long, there is a much smaller financial benefit for this behaviour compared to the other energy behaviours within the period (i.e. 2007 to 2020) under consideration (see Figure 3-2 in Box 3-4) due to the comparatively high associated capital costs.

Potential implications of missing information on costs and benefits

3.32 The table in Box 3-2 shows that there are a number of associated, non-quantified 'costs', such as perceived noise and visual intrusion, which could worsen the subsequent economic assessment of the ***"install domestic micro-generation"*** behaviour, even though some of these could be mitigated by improved design and the location of equipment.

3.33 On the other hand, one of the potential advantages of installing domestic micro-generation is that, by opting to use a distributed, local solution for their own energy needs, householders, communities, businesses and schools can move from being passive consumers of energy to become producers, making an active contribution to energy and climate goals, which could be an attractive proposition. Distributed energy can increase overall system efficiency, as the losses that occur in electricity and heat transportation are reduced, leading to lower generation requirements and consequently lower CO_2e emissions. Therefore, micro-generation might be a cost-effective solution for households in certain areas of the country, where per household infrastructure costs are significantly higher. Domestic micro-generation can be installed and connected relatively quickly and takes on added importance in the face of the 2020 renewable energy target.

Summary

3.34 As with the other headline behaviour goals discussed in this section, the data used for the assessment of the costs of the ***"install domestic micro-generation"*** behaviour are reasonably robust, due to the fact that it has already been used in

[25] Our energy challenge: power from the people. Microgeneration strategy; see http://www.berr.gov.uk/whatwedo/energy/sources/sustainable/microgeneration/strategy/page27594.html

[26] http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

policy assessment (although note that more recent data has been recently published, as noted above). However, for the ***"install domestic micro-generation"*** behaviour, the inclusion of the missing costs, even though they are not likely to be significant, is likely to make its economic assessment worse, although there are wider benefits that were outside the scope of this project. Under the illustrative *concerted* scenario, there is the potential to deliver nearly 10 $MtCO_2e$ savings in England, while additional savings of over 10 $MtCO_2e$ could be attained under the *far reaching* scenario.

Concluding comments on the three energy headline behaviour goals

3.35 As discussed above, the three energy headline behaviour goals presented in this section have been discussed in such detail as the underlying data is considered to be more robust than the data that underlies the other behaviours. This is in part due to the fact that a significant amount of policy attention has already been paid to these behaviours and that, as a consequence, a significant amount of consistent and comparable data already exists.

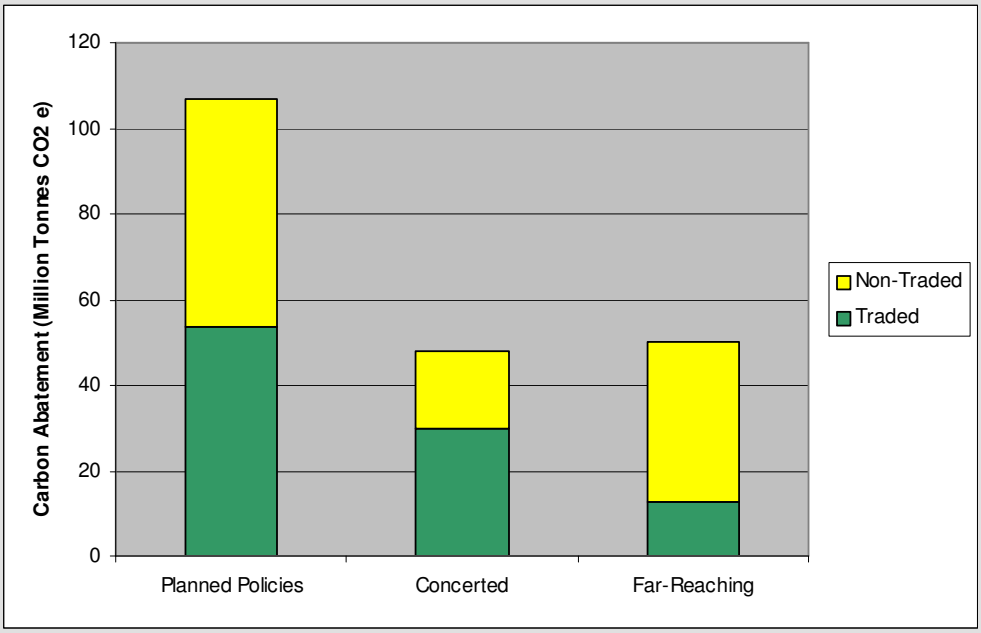
3.36 Together, the three energy headline behaviour goals discussed in this section have the potential to save nearly 50 $MtCO_2e$ in England if adopted at the levels assumed by the illustrative *concerted* scenario, of which nearly 20 $MtCO_2e$ savings would occur in the non-traded sectors (see Figure 3-4 in Box 3-5). Additionally, if rates of uptake reached the levels anticipated under the illustrative *far reaching* scenario, further savings of around 50 $MtCO_2e$ could be achieved, nearly 40 $MtCO_2e$ of which would occur in the non-traded sectors. If planned policies delivered as anticipated, over 100 $MtCO_2e$ reduction would be delivered, of which nearly 55 $MtCO_2e$ would be in the non-traded sectors (again see Figure 3-4). Of the three behaviours, the abatement potential from the ***"install domestic micro-generation"*** behaviour is smallest, but this corresponds to much lower levels of uptake than has been assumed for the actions under the other two headline behaviour goals (see Table 2-1).

3.37 The savings for both the ***"install insulation"*** and ***"buy energy efficient products"*** behaviours are also cost-effective in terms of reducing CO_2e emissions, whereas the ***"install domestic micro-generation"*** is *currently* a cost ineffective means of reducing CO_2e due to the relatively high capital costs. This is due to the potential financial benefits to a household of adopting the first two behaviours (of nearly £160 a year for both of the behaviours), and the comparatively minor savings associated with the final behaviour (see Figure 3-2).

Box 3-5: Total cumulative CO_2e abatement potential (2007 to 2020) broken down by traded and non-traded emissions and illustrative scenario

Figure 3-4 shows the aggregate CO_2e abatement potential that might be delivered over the period from 2007 to 2020 split by traded and non-traded emissions for the three energy headline behaviour goals discussed in this section. Note that while the figures for the *concerted* scenario are compared to the baseline, the figures for the *far reaching* scenario ***are additional*** to the emissions savings achieved under the *concerted* scenario. For some of the headline behaviours, it was easy to identify whether the emissions savings achieved would be in the traded sector or not, e.g. all the emissions associated with the ***"Install insulation"*** are not in the traded sector (assuming that gas is generally used to heat homes; see also Figure 3-1 in Box 3-1). For other behaviours, e.g. ***"install domestic micro-generation"***, savings could be either traded or non-traded, depending on whether gas for heating or electricity used for other purposes was being replaced; in such cases, suitable assumptions were made to allocate the emissions between those in the traded and non-traded sectors.

Figure 3-4: Total cumulative CO_2e abatement potential (over 2007 to 2020) by traded/non-traded emissions and illustrative scenario



3.38 The financial costs associated with micro-generation (both absolute and relative) are, however, likely to come down over time. Additionally, as a result of the

increases in system efficiency that micro-generation can deliver, due to a reduction in the heat and electricity losses that occur during transportation, micro-generation could be a cost-effective solution for households in certain areas of the country, where per household infrastructure costs are significantly higher.

4 Overview of results for the other headline behaviour goals

4.1 As noted above, this section ***discusses the approach and aggregate results relating to the nine headline behaviour goals not discussed in the previous section***. In other words, it presents the approach and findings relating to those behaviours for which there was a relatively lower level of confidence associated with the data used and, consequently, the results. As noted in paragraph 1.11, a quantitative assessment was undertaken for only eight of these nine behaviours (as such an assessment was not undertaken for the ***"avoid unnecessary flights (short haul)"*** behaviour), hence the aggregate results are for these eight behaviours; the ***"avoid unnecessary flights (short haul)"*** behaviour is only discussed qualitatively. As noted above, in the course of the project many assumptions had to be made and so there is relatively less confidence in the results discussed in this section. Consequently, the results in this section are only presented at the aggregate level and are compared to the aggregate results for the three energy headline behaviour goals presented in Section 3. This approach enables an aggregate figure for the first order potential impact of changing behaviour to be presented for the eight behaviours for which a quantitative assessment was undertaken.

4.2 The section begins by discussing the general approach taken for each of the nine headline behaviour goals addressed in this section and notes the issues that arose in the course of the project in relation for each. This includes reference to the caveats set out in Box 1-1 and a discussion of the potential impacts of addressing these caveats.

4.3 After the general approach has been outlined, the results of the assessment are presented at the aggregate level for eight of the nine behaviours. The set of results presented is not consistent with that of Section 3, as the cost effectiveness of the adoption of these headline behaviour goals is not a meaningful number. Hence, the following results are presented in this section:

- Total cumulative CO_2e abatement potential for the period 2007 to 2020 by group of behaviours (i.e. the group of three behaviours discussed in Section 3 versus the group of eight behaviours for which the results of the quantified assessment are discussed in this section) broken down by illustrative scenario; and

- Financial savings per household by group of behaviours.

Approach and issues

4.4 As highlighted in previous sections, while there was a fair degree of confidence in the results for the three energy headline behaviour goals discussed in the previous section, there was less confidence in the results for the other nine behaviours. This lack of confidence exists for a number of reasons.

4.5 First, the choice of actions under many of the other nine headline behaviour goals was less well developed than it was for the three energy behaviours. Generally, the selection of actions was made on basis of prominence of the action within existing environmental discourse (i.e. it has emerged as a relevant pro-environmental behavioural action); the merit of the action in terms of financial saving and emissions reductions (and therefore the probability that it will retain its prominence in the future); as well as the availability of the kind of data required for the project. In most cases, the energy actions have undergone further development in all three of these areas, relative to these other nine behaviours.

4.6 For example, in relation to the fourth energy headline behaviour, the ***"better energy management in the home"*** behaviour, the data used for the assessment of the costs were reasonably robust, as these were taken from similar sources as the data underlying the other three energy headline behaviour goals, e.g. MTP (2008), as well as EST (2008) (see Annex E). The general assumption behind the actions was either that energy-consuming devices were turned off when not in use (e.g. lights were turned off when no-one was in the room and stand-by was not used) or that lower temperatures were acceptable (either for heating or laundry), which subsequently led to an energy saving.

4.7 However, the list of actions that could contribute to better energy management in the home is potentially broad, as there are many energy-consuming products that could be turned off when not in use, so only a subset of the potential actions could be assessed in this report. Additionally, there was less confidence in the data that was used for this headline behaviour goal than for the other three energy goals; hence, there is less confidence in the associated results. It is therefore likely that the potential savings from this behaviour have been underestimated.

4.8 It was similarly difficult to identify and assess a comprehensive set of actions

to operationalise the ***"use car less"*** behaviour. There are many ways and means of using a car less. The actions chosen to represent this behaviour were those that represented a range of potential actions, but clearly it was not possible that these were comprehensive. So, for the actions under the transport behaviour it was assumed that:

- **Commuter lift-share:** Two people share a car to the same place of employment rather than use two cars, that both households involved use a conventional vehicle and that the operational cost saving is shared between the two households.
- **Walk or cycle to school/work:** The household concerned replaces the use of a conventional car (for a journey of under three miles) with a journey on foot/by bicycle.
- **Walk for shopping:** All existing car journeys under one mile (using a conventional car) for shopping are replaced by journeys on foot.
- **Replace car ownership with car club membership:** Those who join a car club sell a car and end up travelling 65% fewer miles each year as a result of joining the car club.

4.9 These actions were considered to cover some of the key types of journey that rely on a car (as indicated by successive National Travel Surveys), and include potential means of reducing car use in undertaking these journeys. Clearly, however, car journeys are undertaken for other reasons, including personal business (e.g. visiting banks, doctors, etc) and for social reasons, so there are more journey types that could have been included. Additionally, the assumptions were very much concerned with replacing like-for-like, i.e. a journey to school by car is replaced by a similar one on foot, but again, the response is likely to be more complex than this as a journey by foot takes more time (so the walk to school by the parent/guardian might be combined with another purpose) and allows for fewer goods to be carried (a separate journey might have to be undertaken if the car journey to school was previously combined with a trip to the shops). Hence, the assumptions do not capture the potential complexities involved; so it was especially difficult to operationalise this behaviour in a way that could be considered to be comprehensive.

4.10 For the actions under this behaviour, there were no financial capital costs, as the actions generally consisted of not doing something or doing an alternative for which it was assumed that the means were already available. However, there were financial savings to the households concerned in terms of saved fuel costs. It should be noted, however, that there are significant barriers to the uptake of the actions associated with this behaviour (as otherwise people would adopt the behaviour in order to benefit from the potential financial savings), which are discussed below (see

paragraph 4.44).

4.11 The most obvious example of a vague headline behaviour goal (as mentioned in Box 1-1) for which it was not possible even to determine in any meaningful way what this behaviour meant in practice was the ***"avoid unnecessary flights (short haul)"*** behaviour. In theory, not taking unnecessary flights would clearly be beneficial for the environment, if 'unnecessary' is interpreted as flights that bring no other social or economic benefit. However, what this means in practice is a lot more difficult to determine. Hence, it was decided not to include this behaviour in the quantitative assessment that was undertaken as part of this project. It is worth noting at this point that Defra is planning to review the twelve headline behaviour goals, so difficulties with the definition of this behaviour could be addressed at that time.

4.12 As with the other transport behaviours, identifying a comprehensive set of actions that might potentially contribute to the third transport behaviour ***"use more low energy consuming vehicles"*** was not easy. The actions chosen were not strictly means by which the behaviour could be achieved, as any vehicle requires energy to make it move, so alternatively fuelled vehicles such as hybrids, are not technically 'low energy consuming vehicles'. This is potentially another definitional issue that could be addressed in the course of Defra's forthcoming review.

4.13 The actions chosen behaviour for the ***"use more low energy consuming vehicles"*** were arguably the main ways in which the CO_2e emissions resulting from the purchase of alternative vehicles operated by households could be achieved from the perspective of the household, although it would be relatively easy to propose alternative actions. Generally, it was assumed that a householder replaced an existing car with a similar-sized vehicle (so that there was no reduction in utility in this respect) using a more energy-efficient fuel at the end of its life. Hence, for the 'replace a petrol car with a diesel car' action, it was assumed that householders replaced a standard petrol Ford Focus (i.e. the most common model of car in the UK being top of both the new cars sold and second-hand cars sold lists in early 2007) with the most efficient Ford Focus diesel of an equivalent size. Similar comparisons were made for the 'replace a petrol car with a hybrid car' and 'replace a petrol car with an electric car' actions (see Annex E for more detail).

4.14 The information underlying the ***"waste less food"*** behaviour was brought together from only two sources – WRAP (2007) for the data on the amount of food wasted and ERM (2006) on CO_2e emissions per tonne of food waste – which were prepared for different reasons. For the purposes of this project, it was assumed that

all of the food currently wasted was instead eaten. The benefits in terms of costs and CO_2e abatement potential, therefore, were those associated with the food that no longer had to be bought due to other food no longer being wasted. However, these estimates are inexact; it was difficult to obtain estimates for the CO_2e emissions per tonne of food disposed (in order to determine the CO_2e saved by not wasting food) and the estimate used seems to imply a high rate of landfill gas recovery that is possibly unrealistic.

4.15 There are no direct financial costs to the household of adopting the ***"waste less food"*** behaviour; indeed there are only direct financial benefits (resulting from the need to buy less food). However, as with other behaviours, given that there are benefits that households currently appear to be willing to overlook, it suggests that the additional time required to plan meals, etc. is a significant (see the discussion that begins in paragraph 4.44).

4.16 Similarly, the assessment of the costs and benefits associated with the ***"eat more food that is locally in season"*** behaviour were also taken from only two sources, i.e. AEA (2005) for CO_2e savings and Garden Organic (2007). While both apparently were thorough (see Annex E), the findings should be treated with caution, as, in common with other behaviours, there are a number of costs and principally benefits that are not quantified, which would have an impact on the economic assessment of the behaviour.

4.17 For two of the actions under this behaviour, i.e. 'avoid air-freighted produce' and 'avoid imported food where regional, in-season alternatives are available', it was simply assumed that, respectively, air-freighted and imported food were always avoided (in favour of regional, in-season produce) where possible. However, it was difficult to identify any financial costs or benefits associated with adopting these two actions, as it was not possible to identify differences in costs between, in the first instance, air-freighted and non-air-freighted food and, in the second, between imported food and seasonal food grown regionally in the UK. Hence, in the absence of any data it was not possible to make an estimate for any direct financial costs or benefits from avoiding such food.

4.18 For the other action 'grow own vegetables', the Garden Organic study reported that participants were on average getting 52% of their fruit and vegetables from growing them themselves and making a cost saving of £337 a year. That figure implies they were eating substantially more fruit and vegetables than average. However, the costs of growing the food were not quantified so it was not possible to

calculate the net saving (or cost). An additional issue is the substantial time commitment involved (on average 10 hours a week).

4.19 Three of the four actions chosen to represent the ***"adopt a low impact diet"*** behaviour were effectively different stages of reducing the consumption of meat and dairy produce, i.e. eating less meat ('eat no more than three portions of meat per week'), eating no meat (i.e. 'adopt a vegetarian diet') and eating no animal produce (i.e. 'adopt a vegan diet'). Hence, it is important to note that these three actions are not direct alternatives, i.e. if a vegan diet is adopted, then so have (by default) the vegetarian and eat less meat actions. Additionally, a 'buy no food grown in heated greenhouses' action was assessed, which could be additional to any of the other three.

4.20 The financial savings for the diet actions were the differences in the costs of food associated with the different diets, e.g. less meat and dairy produce, and were estimated using data from Defra's Family Food 2006 datasets, and estimates of average consumption by type of diet and CO_2e abatement from the Stockholm Environment Institute. It was not possible to identify data on the price differences between food grown in heated greenhouses and food grown outdoors in southern Europe, so it was assumed that these were the same.

4.21 As with the ***"better energy management in the home"*** behaviour, the actions chosen for the data for the ***"more responsible water usage"*** behaviour were not necessarily all the actions that a household might take to improve its water efficiency, but were those for which data was available from respected sources. These data were supplied by Defra and used in combination with information taken from the Waterwise website and other sources (see Annex E for more information). Given the obvious scope for variability between household type and size, conservative assumptions were used to estimate potential savings. These were effectively associated with an average household taking up each of the water efficiency measures and the financial savings of this lower water use to metered households (clearly non-metered households would receive no financial benefits from taking these actions). The CO_2e savings resulting from the adoption of the actions under this behaviour are both from embedded CO_2e (i.e. the CO_2e emitted in the course of the treatment and transfer of the water that will not be emitted as less water needs to be treated and moved) and CO_2e savings resulting from the need to use less energy to heat water for the 'replace a regular bath with a shower' and 'use dishwasher only when full' actions (see Table 2-1). These benefits are of course

associated with the adoption of this behaviour by both metered and non-metered households, as is the reduction of pressure on water resources (see below).

4.22 For the ***"increase recycling and segregation"*** behaviour, one of the key issues is the lack of direct financial benefits for the household in adopting this behaviour, while there are potential direct costs associated with the increased time, energy and space implications of these actions for households. Benefits to the household principally take the form of non-quantified 'feel good' benefits from cutting down on household waste rather than any direct financial benefit. Little research has been undertaken on the latter; the only study identified was for Norway, and it was considered that it was probably not appropriate to translate these findings to the UK context. Data on waste streams and the potential CO_2e benefits of recycling was provided by WRAP and was available in Defra (2007), respectively. Conservative estimates were used to determine the potential CO_2e benefits of taking up the actions. As with water, the CO_2e benefits are embedded, i.e. they are life cycle savings associated with changes to the treatment and transport of waste, as well as the benefits associated with lower extraction of primary resources.

4.23 Additionally, as noted above (paragraph 2.9) it was not possible to identify a baseline consistent with the EWP for all but one of the nine behaviours discussed in this section. In such case, the additional uptake above 2007 levels under the baseline was thus generally taken to be zero, which is clearly unlikely to be the case, as the adoption of some of the actions could be increasing due to increasing environmental awareness and knowledge about health impacts, e.g. those relating to diet, in the absence of additional policy measures. On the other hand, behaviours such as ***"use car less"*** are being influenced by a range of potentially competing factors, e.g. the sustainable transport message of local and national authorities competing against the economic and social benefits of the car. Hence, in cases where there is increasing uptake in the absence of policy measures, the benefits associated with the *concerted* scenario are likely to be overestimates (as those associated with the baseline are likely to be underestimates) and vice versa.

4.24 As noted in paragraph 2.11, for the ***"better energy management in the home"*** and ***"increase recycling and segregation"*** behaviours, it was agreed that the baseline uptake should be half that of the *concerted* scenario, as there are government-funded bodies in place to encourage these behaviours. This is a relatively arbitrary assumption, but it was considered to be likely to be closer to the potential truth than assuming no additional uptake beyond 2007 levels. Hence,

whether the benefits estimated as being associated with the *concerted* scenario would be an under- or overestimate of the eventual benefits would depend on whether the chosen assumption over- or underestimates the baseline.

Results of the assessments

4.25 As noted in Box 1-1, for all of the behaviours assessed in this project, it was not possible to identify a comprehensive set of quantified estimates of costs and benefits. Consequently, the results of the assessment discussed in this section are based only on an assessment of the direct financial costs and benefits to the household. The potential impact of unquantified costs and benefits is discussed in the following section (see paragraph 4.34).

Comparing the relative CO_2e abatement potential

4.26 As can be seen in Figure 4-1 (see Box 4-1), the eight quantified behaviours discussed in this section have the potential to deliver around 75 $MtCO_2e$ savings in England if they were adopted at the rates assumed under the illustrative *concerted* scenario. Under the *far reaching* scenario, there is the potential for additional abatement of around 230 $MtCO_2e$. It is worth noting that the abatement potential of these eight behaviours is larger than that of the three energy headline behaviour goals presented in the previous section. This is in part due to there being more headline behaviour goals (i.e. eight as opposed to three), although under the illustrative *far reaching* scenario, there is a larger *average* CO_2e abatement per headline behaviour goal (nearly 30 $MtCO_2e$ each compared to less than 15 $MtCO_2e$ each for the three energy behaviours). If they deliver as anticipated, planned policies would deliver a cumulative saving of around 50 $MtCO_2e$ between 2007 and 2020.

4.27 The indication that most of the CO_2e reductions associated with these eight behaviours occur under the *far reaching* scenario and relatively little occurs under planned policies reflects the lower level of policy attention paid to these behaviours in general, and hence the zero additional uptake assumed in the baseline for many of these behaviours (paragraph 2.9). Having said that, the estimates do suggest that there is room for significant CO_2e savings from non-energy domestic actions.

4.28 It is important to note that the potential CO_2e abatement from many of the other non-transport behaviours comes from either a reduction in transport, e.g. ***"eat more food that is locally in season",*** or from potential savings from embedded CO_2e, i.e. the CO_2e saved from the production or processing of a product that is used less as a result of the behaviour, e.g. ***"increase recycling and segregation"*** and

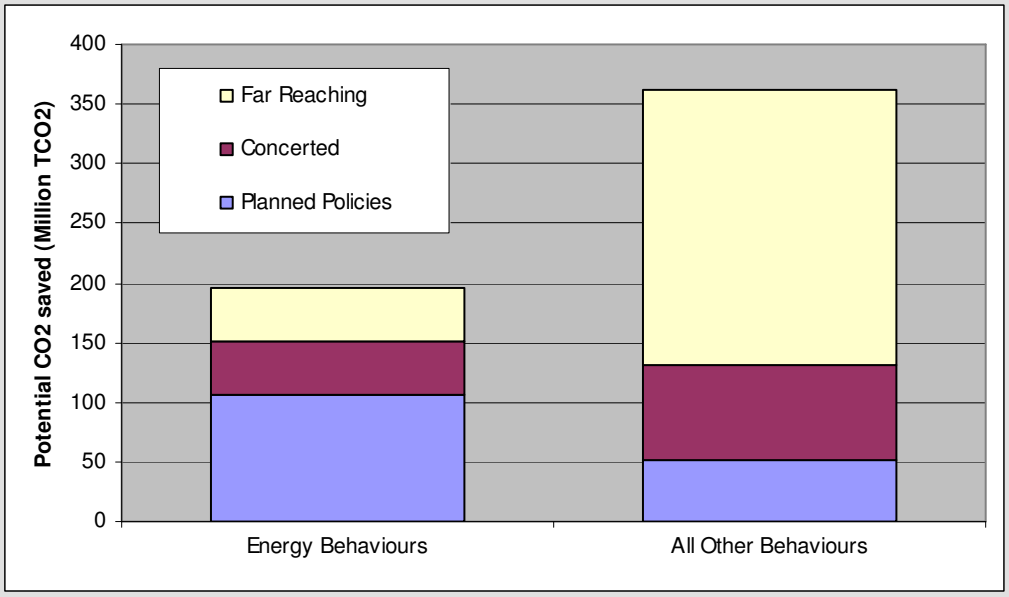
"more responsible water usage".

4.29 ***Additionally, some of the CO_2e abatement potential that is included in the results for some of the behaviours could occur outside the UK***, e.g. for the recycling behaviour. In such cases, any CO_2e abated would not contribute to the UK's emissions reductions under the Kyoto Protocol and subsequent international agreements.

Box 4-1: Total cumulative CO_2e abatement potential (2007 to 2020) by group of behaviours broken down by illustrative scenario

Figure 4-1 shows the aggregate CO_2e abatement potential that might be delivered over the period from 2007 to 2020 ***for the eight behaviours*** discussed in this section (excluding the ***"avoid unnecessary flights (short haul)"*** behaviour as this was not quantified), as well as the equivalent aggregate figure for the three energy behaviours discussed in the previous section. The disaggregated figures for the behaviours discussed in this section are not presented due to the lower levels of confidence in these results (for the reasons discussed above).

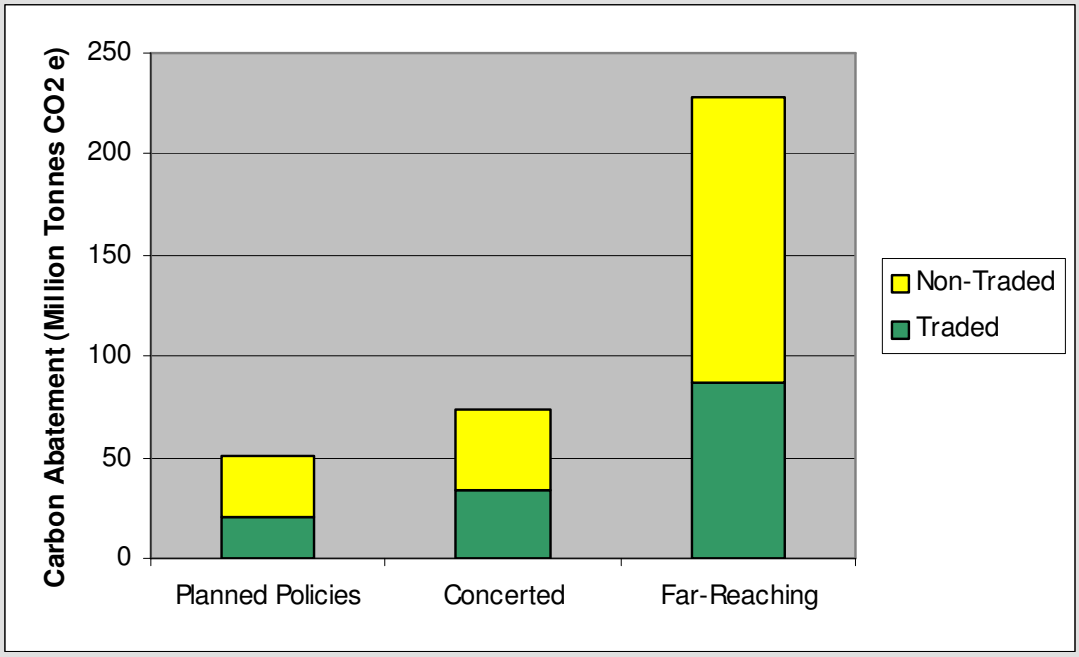
Figure 4-1: Total cumulative CO_2e abatement potential (over 2007 to 2020) by group of behaviours broken down by illustrative scenario



Box 4-2: Total cumulative CO_2e abatement potential (2007 to 2020) broken down by traded and non-traded emissions by illustrative scenario

Figure 4-2 shows the aggregate CO_2e abatement potential that might be delivered over the period from 2007 to 2020 split by traded and non-traded emissions for the ***eight behaviours for which a quantitative assessment*** was undertaken. Note that while the figures for planned policies relate to achieving the baseline and the *concerted* scenario is compared to the baseline, the figures for the *far reaching* scenario ***are additional*** to the emissions savings achieved under the *concerted* scenario. For some of the headline behaviours, it was easy to identify whether the emissions savings achieved would be in the traded sector or not (e.g. see Box 3-5). For those behaviours for which the reduced emissions where from aviation (e.g. the ***"eat more food that is locally in season"*** behaviour), the inclusion of aviation in the EU emissions trading scheme from 2012 was taken into account. For other behaviours, notably ***"increase recycling and segregation"*** savings from embedded CO_2e emissions could be either traded (e.g. reducing the electricity needed in the processing of resources) or non-traded, e.g. reduced emissions from landfill; in such cases, suitable assumptions were made to allocate the emissions between those in the traded and non-traded sectors.

Figure 4-2: Total cumulative CO_2e abatement potential (over 2007 to 2020) by traded/non-traded emissions by illustrative scenario



4.30 Figure 4-2 (see Box 4-2) shows that under the illustrative *concerted* scenario, of the 75 $MtCO_2e$ emissions that could be saved around 40 $MtCO_2e$ emissions could be saved in the non-traded sectors. Under the illustrative *far reaching* scenario, of the potential 230 $MtCO_2e$ savings that could be achieved around 140 $MtCO_2e$ would be achieved in the non-traded sectors. This is in addition to the delivery of anticipated CO_2e emissions savings from planned policies, which could total over 50 $MtCO_2e$ of which around 30 $MtCO_2e$ savings would be in the traded sector.

4.31 It is important to make a distinction between the CO_2e potential savings in the traded and non-traded sectors, as the former contribute to meeting the cap set by the EU ETS, but will not result in lower CO_2e emissions across the EU as a whole. Any emissions savings resulting from domestic behavioural change will either enable the industry concerned to purchase fewer allowances (if it would otherwise have exceeded its emissions target) or provide the industry with additional allowances to sell (if it brings the industry's emissions under its target). This has a knock-on effect that higher levels of emissions would effectively be allowed elsewhere in the scheme – either by other industries in the UK or by industry, including the electricity generation sector, in other EU Member States – as there would be more allowances on the market.

Benefits per household

4.32 Figure 4-3 suggests that the potential financial savings to a household of adopting the eight other, primarily non-energy, behaviours are potentially more significant than those to be gained from adopting the three energy behaviours discussed in Chapter 3. While, a household could save over £300 a year from adopting the three energy behaviours (see Figure 3-2), it could potentially save nearly £1,800 a year from adopting the actions under the other behaviours. This is not surprising given that many of these actions result in wasting less food, water or energy (see Table 2-1). However, it should be noted that there is a higher degree of uncertainty associated with these behaviours (hence the fact that the results for these are presented in the aggregate only) and that there are significant barriers to the adoption of many of these behaviours (see paragraph 4.44).

Potential implications of missing information on costs and benefits

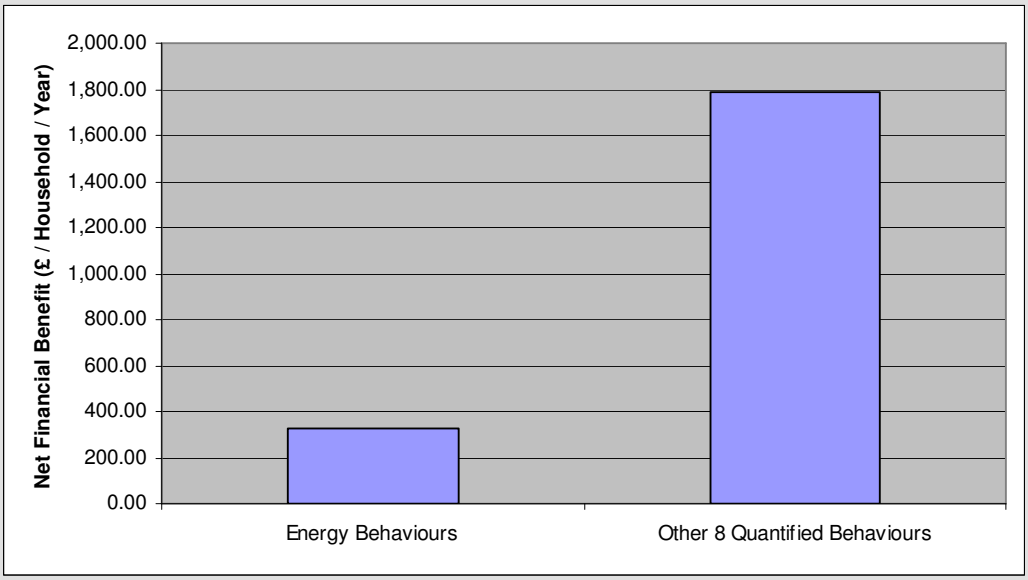
4.33 As noted above, presenting the aggregate cost-effectiveness for the headline behaviours discussed in this section was not meaningful. However, due to the uncertainty associated with the respective cost-effectiveness assessments, the

results for each individual headline behaviour goal are also not presented. However, it is still relevant to consider the potential impact of the inclusion of the missing costs and benefits, as the inclusion of these would, in turn, impact on the potential CO_2e abatement and the potential benefits to the household (i.e. the numbers presented in Figure 4-1 to Figure 4-3).

Box 4-3: Financial savings per household by group of behaviours

Figure 4-3 shows the ***maximum potential annual financial benefit*** for an ***average*** household of adopting all of the ***possible*** actions of, respectively, the three energy behaviours and the other eight quantified behaviours. As noted above, the actual costs and benefits will vary by household; mutually-exclusive and overlapping actions are also taken into account (see Box 3-3).

Figure 4-3: Average, maximum potential net annual financial benefits for households of taking up each group of headline behaviour goals



4.34 There are a range of unquantified costs and benefits associated with the behaviours discussed in this section that have the potential to influence the aggregate results discussed above. Table 4-1 assesses these wider environmental, social and other impacts qualitatively to indicate how their respective inclusion may have influenced the results. Additionally, it should again be recalled that second order (rebound) effects and wider costs and benefits were not included in the assessment – see, respectively Sections 5 and 6 for a discussion of how these elements might be included in a wider, future assessment.

Table 4-1: Qualitative assessment of the potential inclusion of the missing costs and benefits in the results relating to the other eight quantified behaviours

	Impact	Energy Management	Energy Efficient Vehicles	Use Car Less	Waste Less Food	Local / In Season Food	Low Impact Diet	Responsible water usage	Increase Recycling
Environment	Noise	✔	✔	✔	–	✔ ✖	–	–	–
	Local Air Quality	–	✔ ✖	✔	–	✔ ✖	–	–	–
	Odours	–	✔	–	✔	–	–	–	–
	Landscape	–	–	–	–	–	–	–	–
	Townscape	–	–	–	–	–	–	–	✖
	Heritage	–	–	–	–	–	–	–	–
	Biodiversity	–	–	–	–	✔	–	–	✔
	Water resources	–	–	–	–	–	–	✔ ✔	–
Health and Safety	Physical Fitness	–	–	✔ ✔	–	✔	–	✔	–
	Safety	–	✖	✖	–	–	–	–	–
	Security	✖	–	✖	–	–	–	–	–
	Disadvantaged groups	✔	–	–	–	–	–	–	–
	Health	✖	–	✔	–	–	✔ ✔	–	✔
	'Well-being'	✔	✔	✔	✔	✔	✔	✔	✔
Barriers	Time	–	–	✖✖	✖	✖	✖	✖	✖
	'Hassle'	✖✖	–	✖✖	–	✖	✖	✖✖	✖✖
	Sacrifice of Service	✖	✖	✖✖	–	✖✖	✖✖	✖✖	–

4.35 As can be seen from Table 4-1, the inclusion of the unquantified benefits of some of the behaviours on local noise and air pollution could positively impact on the assessment of these behaviours. At the margins, any reduction in noise and the emission of local air pollutants under both the ***"use more low energy consuming vehicles"*** (due to the fact that electric and hybrid cars can be quieter and emit less local air pollutants) and ***"use car less"*** behaviours would not be significant. However, if the use of electric and hybrid vehicles were taken up to the degree implied by the *concerted* and *far reaching* scenarios, i.e. 17% hybrids and 10% electric cars (see Table 2-1), then the positive impact on noise and air quality, in urban areas in particular, could be significant. Note that this may be offset somewhat by the rebound effect which may lead to increased congestion. Alternatively, under the action of replacing a 'petrol car with an equivalent diesel car' (under the ***"use more low energy consuming vehicles"*** behaviour), the impact on air quality is likely to be negative, as diesel cars produce more of certain pollutants, such as particulate matter, than petrol cars.

4.36 On the other hand, for the behaviour that relies on fewer flights being undertaken, i.e. ***"eat more food that is locally in season"***, there will be positive local impacts on air quality and noise around airports. Elsewhere, there could be marginal increases in the emission of local air pollutants and noise caused by any subsequent increase in the number of road transport journeys. At the margins, the

impact of this on the overall assessment would be small, but if there were a significant increase in the number of car journeys, then the associated costs would increase. The net effect of these two opposing impacts depends on local circumstances and has been considered in more detail elsewhere (e.g. see CfIT, 2001)[27].

4.37 One of the main objectives, from the perspective of society as a whole, of reducing water use, is to reduce water extraction from the environment. This factor, although key for the ***"more responsible water usage"*** behaviour, has not been valued as part of this exercise as it is a wider benefit and therefore beyond the scope of the project[28].

4.38 Most of the benefits that could be associated with the ***"increase recycling and segregation"*** behaviour will be at the broader social, rather than household level, such as the reduced need for landfill and incineration and the associated environmental impacts, which are not included in the analysis. Under the ***"eat more food that is locally in season"***, allotments in urban areas might contribute positively to biodiversity, which could make this behaviour more beneficial and therefore cost-effective.

4.39 A potentially significant benefit of adopting a ***"adopt a low impact diet"*** is the effect on health. Evidence suggests that adopting a mostly vegetarian or vegan diet could have considerable health benefits, which if valued could result in a far higher potential value to householders.

4.40 A number of actions under the behaviours potentially improve the physical fitness of those adopting the new behaviour. For example, under the ***"use car less"*** behaviour, the actions that involve more walking and cycling would have the potential to deliver health benefits, which have the potential to be significant for those who adopt a regular and sustained change of behaviour. In relation to growing ones own food under the ***"eat more food that is locally in season"*** behaviour, the potential benefits to health from the greater physical fitness that could arise from regularly working on an allotment is also a potential benefit.

4.41 The potential health benefits of the ***"use car less"*** behaviour need to be balanced by the potential, perceived safety and security implications, for children in particular, of walking and cycling to school. There are also potential costs in relation

[27] http://www.cfit.gov.uk/docs/2001/racomp/racomp/index.htm

[28] Note that the CO_2 associated with reduced water usage is that associated with reduced processing and extraction of water.

to increased safety concerns from an increased uptake of the electric vehicles under the ***"use more low energy consuming vehicles"*** behaviour due to the fact that these vehicles are quieter than conventional petrol or diesel cars (as noted above). Additionally, many households leave some lights for reasons of security to deter crime, so these could perceive the 'switch lights off when not in room' action (under the ***"better energy management in the home"*** behaviour) as a cost.

4.42 Additionally, there may be more general benefits in terms of increases to 'well-being' from undertaking behaviours that are of benefit to the environment. This can apply to virtually any of the actions under any of the behaviours, from ***"increase recycling and segmentation"*** to ***"use car less"***. Additionally increases to 'well-being' could be achieved by, for example, the satisfaction and increased sense of connection with the food that might also result from growing ones own food or a desire to support local producers under the ***"eat more food that is locally in season"***. Indeed, for the ***"increase recycling and segmentation"***, it is clear that a householder who was only considering the quantifiable benefits to themselves would be unlikely to recycle. The widespread incidence of recycling behaviour suggests that, in practice, individuals take other factors into account, which suggests individuals who recycle receive private benefits in the form of increased 'well being'.

4.43 It is worth noting that more detailed work on the cost-effectiveness of waste options in the context of reducing CO_2e emissions has been carried out on behalf of Defra and the Committee on Climate Change[29].

4.44 As can be seen in Table 4-1, there are a number of barriers to the adoption of many of these behaviours that have not been quantified in this project. These could be considered to be the hidden costs of taking up these behaviours. These barriers have been broadly classified as 'time', 'hassle', and 'sacrifice of service'. In practice, such barriers may be the most important factor in explaining why certain behaviours (that might appear to be cost-effective and potentially save people money) are not observed in reality to the degree that might be anticipated from the changes in behaviour modelled in this project without greater intervention.

4.45 In Table 4-1, the barrier of 'time' is relevant for those behaviours that actually require additional time compared to the behaviour that they are replacing. The most obvious example in this respect is the increased time that walking and cycling take compared to taking trips by car under the ***"use car less"*** behaviour. For other

[29] For example, see http://hmccc.s3.amazonaws.com/pdfs/Eunomia%20Waste%20MACCs%20Report%20Final.pdf

behaviours, the additional time required is for the research required in adopting these behaviours, e.g. the actions under the ***"eat more food that is locally in season"*** and ***"adopt a low impact diet"*** behaviours.

4.46 The phrase 'hassle' in Table 4-1 is used to encompass a range of attitudinal, emotional and lifestyle barriers that prevent the uptake of these behaviours[30]. For example, actions under the ***"better energy management in the home"*** and ***"more responsible water usage"*** behaviours require small changes in behaviour, which in the short-term at least, could be seen as a hassle, e.g. remembering to turn off the light switch when leaving the room or to turn off the water when brushing ones teeth. In the medium- and longer-term, however, once the changed behaviour becomes a habit, the 'costs' associated with this hassle are likely to decline significantly. Given that such actions often do not happen, it suggests that there are significant barriers, and therefore costs, to changing such behaviours.

4.47 Similar, potentially short-term, barriers exist to prevent the take up of some of the food behaviours. For example, under the ***"waste less food"***, ***"eat more food that is locally in season"*** and ***"adopt a low impact diet"*** behaviours, there is the 'hassle' associated with the additional planning of menus and cooking the right amount of food, as well as the additional effort needed to review expiry dates and plan to eat food accordingly. As with the ***"better energy management in the home"*** behaviour, as such planning in relation to food does not take place it suggests that many people do perceive such issues as significant barriers to the uptake of these behaviours.

4.48 'Sacrifice of service' relates to those actions that might save money, but which potentially offer less service or benefit. For example, with respect to the electric car under the ***"use more low energy consuming vehicles"*** behaviour, there is a 'sacrifice of service' given that an electric car cannot be used in the same way as a conventional car, due to the fact that it needs regular recharging and has a relatively lower maximum speed. With electric cars, it is these barriers, which are not quantified here, that will dominate household decisions about taking up this action. A similar 'sacrifice of service' could be considered to be a barrier to the ***"use car less"*** behaviour, as, for example, more shopping journeys might be required to replace a car journey to the shops. Additionally, public transport is often not as flexible as travelling by car, even locally, and in some cases more journeys and additional

[30] Clearly another term could be used instead of 'hassle' but the word can easily be taken to cover all those issues that prevent someone from doing something that are in addition to any extra time required.

logistical arrangements might be required.

4.49 It is important to note that these issues have been widely recognised by different Government departments and agencies. For example, over the past three years, the Department for Transport has been building up its understanding of the issues that need to be considered in facilitating and encouraging sustainable and low CO_2 emissions behaviours building on the evidence base review of public attitudes to climate change and travel choices that was published in 2006[31].

Concluding comments on the other nine headline behaviour goals

4.50 This section has underlined the difficulties associated with estimating the costs, benefits and associated CO_2e abatement potential of changing household behaviours. The eight quantified behaviours for which the aggregate results were discussed in this section have the potential to deliver more CO_2e savings with greater financial benefits to the average household than do the three energy behaviours discussed in Section 3. However, it is important to note that there is more uncertainty associated with these eight behaviours.

4.51 We have estimated that together, the eight headline behaviour goals quantified and presented in this section have the potential to deliver an additional 75 $MtCO_2e$ abatement (of which around 40 $MtCO_2e$ savings would be in the non-traded sectors) between 2007 and 2020, if the actions were adopted at the rates indicated by the illustrative *concerted* scenario. This compares to nearly 50 $MtCO_2e$ for the three energy behaviours (of which nearly 20 $MtCO_2e$ would be in the non-traded sectors). Nearly 230 $MtCO_2e$ savings (compared to around 50 $MtCO_2e$ for the energy behaviours) could be delivered under the illustrative *far reaching* scenario, of which around 140 $MtCO_2e$ would be in the non-traded sectors.

4.52 Together, under the illustrative *concerted* scenario, the eleven headline behaviour goals that were quantified have the potential to deliver an additional 120 $MtCO_2e$ abatement (between 2007 and 2020) of which nearly 60 $MtCO_2e$ would be in the non-traded sectors (see Figure 3-4 in Box 3-5 and Figure 4-2 in Box 4-2). Under the *far reaching* scenario, around 280 $MtCO_2e$ savings could be delivered of which nearly 180 $MtCO_2e$ would be in the non-traded sectors (see the same boxes referred to for the *concerted* scenario). These aggregate numbers are presented in full in Table 7-1.

[31] Findings from a deliberative research study exploring the public's engagement with climate change and the barriers and motivators to transport behaviour change were published in Jan 2009. See http://www.dft.gov.uk/pgr/scienceresearch/social/climatechange/

4.53 The maximum potential financial savings to an average household of adopting all of the eleven headline behaviours are more than £2,100 of which the vast majority (nearly £1,800) would be by adopting the eight behaviours in which there is less confidence (see Figure 4-3 in Box 4-3).

4.54 It should be recalled, however, that these are first order estimates that do not take into account a number of costs and benefits, including the barriers to the adoption of the behaviours that were discussed above. Additionally, no attempt was made to estimate the impact of second order (rebound) effects or the wider costs and benefits. If it were possible to estimate the monetary value associated with all these elements and to include these values into the assessment, there is no doubt that the numbers would be different. However, the numbers presented are a first attempt at identifying the first order impacts of household behavioural change on CO_2e emissions.

5 Modelling the expenditure of income saved from behavioural change

5.1 Sections 3 and 0 outlined the potential costs, benefits and CO_2e abatement potential of different degrees of behavioural change associated with the twelve headline behaviours that are the subject of this report. Following any such behavioural change, a household would redistribute any saved expenditure to other areas of household spending or saving. Alternatively, if behavioural change results in increased expenditure on an activity, this would have to be financed by a fall in savings or a fall in expenditure on other goods and services. In either case, there is likely to be knock-on effect on household CO_2e emissions since any change in expenditure pattern is likely to change the household carbon footprint. We define this chain of events as the ***rebound effects*** of behavioural change.

5.2 As noted in Section 1, Objective 2 of the project was to propose a methodology to estimate the impact of such rebound effects. This section gives an overview of a possible approach for estimating such impacts. It is important to note that this section is restricted to the financial impacts of behavioural change and the second round effects on CO_2e emissions. However, it should be acknowledged that household consumption of other non-marketed goods may respond in a similar way. In particular, behavioural changes that affect the amount of free time available to the household may have implications for CO_2e emissions. Any impacts of price change brought on by changes in economy-wide changes in demand are considered in Objective 3 (see Section 6).

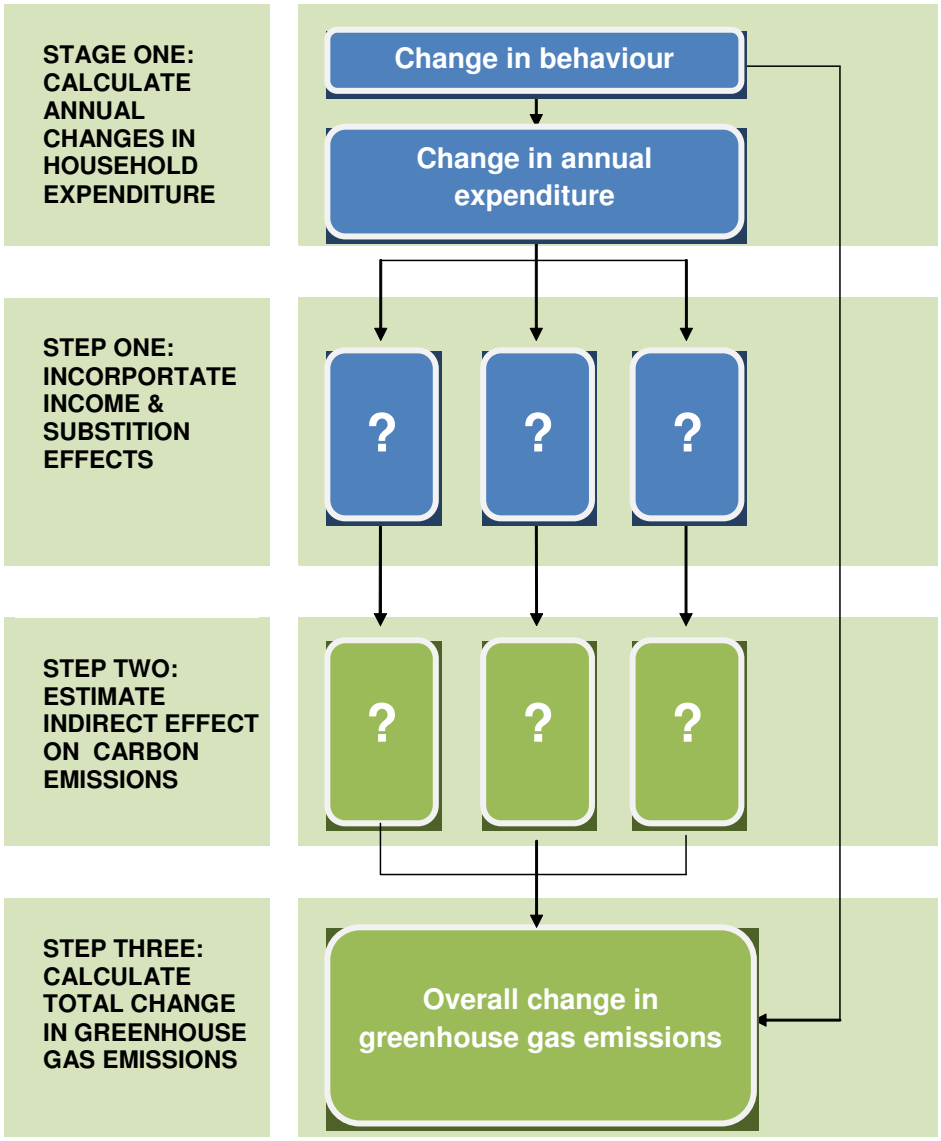
5.3 This section is essentially a summary of a more extensive analysis provided in Annex F, which reviews background literature, gives detailed descriptions of the proposed methodologies and a discussion of potential implementation issues and possible solutions. A review of current knowledge on how policy can act to mitigate potential second round increases in CO_2e emissions is also provided.

Estimation of Rebound Effects

5.4 Rebound effects include both the effects of changes in expenditure on policy-targeted goods (income effects), and for some behaviours, the effects of relative price changes (substitution effects). The proposed method is based on a framework

that relates direct changes in household finances to changes in the allocation of expenditure across different goods and services (see Figure 5-1)[32].

Figure 5-1: Calculation of total change in greenhouse gas emissions



5.5 **Stage one** identifies the financial effects estimated under Objective 1 and expresses these in terms of a time profile, i.e. as an annual series of expenditure changes. A particular determinant of this time profile is the extent to which

[32] We should note also that, in addition to the financial impact of spending any money saved on other carbon emitting activities, in many cases there are likely to be impacts in terms of increasing the level of consumption for the specific behaviour being analysed due to money saved (e.g. switching to a low energy consuming vehicle may result in driving more, or installing insulation may result in turning up the heating to make the room warmer than it was). Equally if certain households use their car less, then other households may use their car more due to less congested roads.

households borrow to finance capital outlays (this is likely to be required for some behaviours) or finance this out of their savings.

5.6 **Stage two** of the proposed approach aims to estimate adjustments to household budgets using estimated income effects for different categories of consumption. Two options for estimating income effects are proposed:

- The first approach is relatively simple and can be implemented using existing data sources. This approach makes the assumption that the share of each good as a percentage of total expenditure remains constant when the members of the household adjust their budget.
- The second approach also models changes in expenditure, though allows for the fact that the share of some goods in total expenditure increases as incomes rise (referred to as luxury goods, such as restaurant meals), while the share of other goods declines (referred to as inferior goods, such as tinned food).

5.7 This second approach is more complex as it requires the estimation of an econometric model using the *Expenditure and Food Survey*[33] data. However, the advantage of this approach is that it would allow the share of each good as a percentage of total expenditure to vary as income changes. This delivers much more realistic outcomes. To illustrate the effects of this, we compare the two approaches in Table 5-1, based on a £15 reduction in the weekly food bill of each household in England[34].

Table 5-1: Comparison of income effects under approaches 1 & 2*

Type of Expenditure	Excluding Rebound Effects	Including Rebound Effects			
		Approach 1	Approach 2	Difference	
Food	£36,051m	£37,277m	£34,468m	-£2,809m	(-7.5%)
Clothing	£26,332m	£27,226m	£28,818m	£1,592m	(+5.8%)
Housing	£76,735m	£79,345m	£77,526m	-£1,819m	(-2.3%)
Fuel	£11,269m	£11,686m	£11,742m	£56m	(+0.5%)
Drink and Tobacco	£12,544m	£12,972m	£13,460m	£488m	(+3.8%)
Transport and Communication	£83,289m	£86,122m	£86,635m	£2,513m	(+0.6%)
Other Goods	£42,831m	£44,288m	£44,674m	£386m	(+0.9%)
Other Services (inc loan repayments, savings)	£209,298m	£216,418m	£218,011m	£1,593	(+0.7%)

*Based on 21.7 million houses in England (Office for National Statistics, *Population of households in England to 2021*). Rounding errors may apply.

[33] See http://www.statistics.gov.uk/ssd/surveys/expenditure_food_survey.asp

[34] The Expenditure and Food Survey is based on a survey of households in Great Britain. Thus, this analysis assumes that English households have the same pattern of expenditure as Great Britain as a whole. While this assumption allows a broad comparison of the two approaches, any future application should calculate the appropriate statistics for England individually.

5.8 Each approach predicts different changes in expenditure for each category. For example if the weekly food bill of the average household in England is reduced by £15, the simple approach (approach 1) predicts an increase in total expenditure by all English households of £1.2 billion on food relative to the baseline, while Approach 2, which is considered more accurate, predicts a decrease of £1.5 billion. A similar pattern is observed for housing. For other categories, Approach 1 would underestimate the change in expenditure. Thus, while Approach 1 is simple to apply there is a distinct penalty in terms of realism and accuracy. The estimated changes in CO_2e emissions as a result of taking Approach 1 would be correspondingly inaccurate.

5.9 For a particular household, this might mean, for example, that the reduction in food bills discussed above could lead to fuel bills increasing by £0.39 to £10.39, while transport and communication expenditure might increase to £76.66 from £73.70 (see Table 22 of Annex F). In other words, a 35% reduction in food bills could result in a 4% increase in both fuel and transport/communications expenditure.

5.10 For behavioural goals that involve efficiency savings the analysis is slightly more complex as there are additional substitution effects that need to be accounted for. Annex F provides more detail on the definition of substitution effects and how to incorporate these in both Approach 1 and Approach 2.

5.11 The redistribution of household expenditure towards (or away from) other categories of goods and services will change their associated CO_2e emissions. Thus, **stage three** of the proposed methodology is to combine changes in spending with data on their respective CO_2e emissions. This would complete the estimation of the rebound effects.

5.12 In **stage four**, direct impacts on CO_2e emissions are combined with the rebound effects to yield an estimate of the net change in CO_2e emissions resulting from each behavioural goal.

5.13 As already alluded to, the most suitable data set for either of the approaches applied is the *Food and Expenditure Survey*. This has several advantages, namely its coverage, scale and longitudinal nature. However, not all of the behavioural goals directly correspond with an expenditure category within the survey data. It is therefore possible that the outputs of this project could help to determine an alternative data collection methodology for the *Expenditure and Food Survey* in future years, ensuring that spending categories relate directly to the potential

behaviours. However, it is important to note that whether such a revision should take place will be dependent on the extent to which Defra commits to measuring and modelling the chosen headline behaviours in the longer-term in this way. Alternatively, it may be possible to design alternative assumptions or approaches for identifying the most suitable approach. Other possible solutions could be achieved econometrically[35], for example.

Policies for Mitigating Rebound Effects

5.14 As noted in Section 1, Defra (2008) identified seven population segments that reflect differences in environmental awareness across different individuals.

5.15 Survey[36] data from these segments show some clear, differential patterns of behaviour among these segments, as would be expected by their attitudes. It is also possible that the rebound effect, expressed in terms of CO_2e emissions, demonstrated by each segment is different. More specifically, it is likely to be lower for more environmentally concerned citizens. Approach 2 for estimating income effects involves estimating a new micro-econometric model. In principle, this would present an opportunity for analysts to investigate whether there are significant differences in rebound effects between different groups. However, this would require additional variables to be included in future rounds of the *Expenditure and Food Survey*.

5.16 Annex F considers the potential for policy to influence household budget adjustments. Two ways that policy might influence secondary spend are explored:

1. Embedded messages at the action level – i.e. raising awareness at the point that the action is adopted in order to influence decisions how any saving is re-spent (or what is cut-back on in cases where there is a cost).
2. An integrated strategy which seeks to influence people's underlying attitudes and preferences across the behavioural change agenda and therefore shift peoples marginal income spending towards lower emissions spending.

5.17 A key challenge centres on understanding the net benefit of financial incentives and how their net effect might be improved by ensuring that they

[35] One potential econometric approach would begin by exploring the statistical difference between income effects in each candidate category, e.g. transport versus recreation and culture

[36] Defra survey of attitudes, knowledge and behaviour in relation to the environment (***JN-45105255***), Defra 2008 (provided directly to the project team)

additionally engage people on their attitudes and preferences. The focus group format, such as that already undertaken to understand the segmentation in the English population (Defra 2008), may be able to increase understanding of the degree that people already link primary behaviour with secondary spending. However, the hypothetical nature of this research technique generally means that it would not provide any sufficient confidence about how people would respond to future policies. It would therefore be necessary to undertake more action-based research at the household or local community level. This might involve investigating how individuals respond to different forms of engagement and the offering of incentives. The impact could be assessed by measuring environmental attitudes (by segment) before and after the engagement and assessing the impact of the change. Such research would closely relate to similar areas of research, such as those intended to find out the potentially catalytic behaviours across goals.

6 Potential impacts of behavioural change on the wider economy

6.1 While Objectives 1 and 2 discussed the effects of the 12 headline behaviours on individual households, the aim of Objective 3 was to consider how widespread behavioural change across large groups of households might affect other parts of the economy or the economy as a whole. This section describes the type of economy wide effects that are likely to result from such behavioural change. A preliminary scoping of impacts is also performed and a brief description of possible approaches for quantifying effects is provided.

Understanding economy-wide effects

6.2 To frame the discussion we identify three separate tiers of impacts. These are organised in a hierarchy and are summarised in Figure 6-1.

6.3 **Tier one impacts** are individual household impacts, as discussed in Objectives 1 and 2. In this analysis, the effects on households are calculated assuming that the economy is unaffected by widespread behavioural change.

6.4 **Tier two impacts** (which can be both direct and indirect) reflect changes to sectors of the economy that occur when large numbers of consumers change their behaviour. ***Direct impacts*** refer to the impacts on sectors or markets principally affected by a change in demand. For example, those directly affected by an increase in demand for hybrid cars include car manufacturers, car dealers, fuel producers, fuel retailers and providers of maintenance services. ***Indirect impacts***, or second round impacts, follow from the interaction between sectors or markets, where one or more of them have been subject to a direct impact.

6.5 To illustrate tier two impacts, we consider the market for hybrid cars[37]. Consider the following hypothetical scenario:

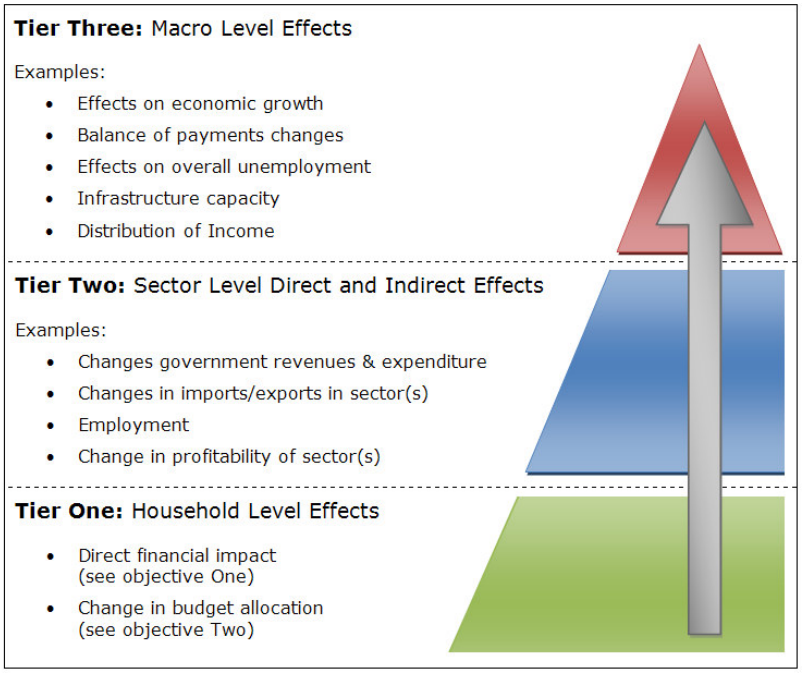
1. Behavioural change causes an increase in demand in the market for hybrid cars, matched by a corresponding decrease in demand in the market for non-hybrid cars. These are direct effects. In the short run,

[37] The interactions described below are for illustration purposes only and are not necessarily representative of the hybrid car market.

hybrid car prices will increase and non-hybrid cars prices will decrease[38].

2. The fall in the relative price of non-hybrid cars makes them more attractive to consumers. Some consumers decide to purchase these instead, offsetting some of the increase in demand for hybrid cars. This is known as a *spill-over effect*.
3. Because the demand for hybrid cars is now slightly lower, this reduces the price of hybrid cars. This is known as a *feedback effect*.
4. The fall in the price of hybrid cars means that the demand for non-hybrid cars decreases, inducing a further feedback effect.
5. Feedback effects continue until a stable price and output level is reached in each market.

Figure 6-1: Hierarchy of Behavioural Change Impacts



6.6 Of course, the speed of adjustment is likely to vary between different markets. We would also expect there to be long-run effects of persistent changes in demand. In particular, hybrid car producers are likely to benefit from economies of scale, leading to a fall in production costs and, assuming that producers pass on a portion of savings to consumers, a fall in price.

6.7 The above example relates to goods that are substitutes in consumption, whereas other goods may be linked because they are complements in consumption, so a fall in demand for one means that the demand for others also falls. Wine and

[38] This assumes that the short-run marginal cost function is upward sloping for hybrid and non-hybrid cars.

restaurant meals are a popular example of such complementary goods.

6.8 There can also be wider impacts, as in many cases different sectors will share inputs and resources. If one sector observes an increase in demand, they will need to increase their use of an input to increase their output. If these inputs are scarce in supply, they may need to increase the amount they pay in order to secure their use.

6.9 There may be linkages between private and public sectors, for example between the demand for car journeys and the demand for the treatment and prevention of health conditions relating to low exercise levels. Almost all behavioural changes will have implications for government revenue and expenditure, not least because all goods are subject to Value Added Tax (VAT). Other goods and services are subject to specific taxes (e.g. fuel and air travel), whilst others are subject to subsidies (e.g. home insulation). There are also likely to be effects on government revenue and expenditure from indirectly effects on other sectors.

6.10 A sector experiencing an increase in output or price is likely to be affected in several ways. This includes, though is not limited to, changes in profitability, employment and growth. The affected sectors will also change the amount of inputs they require for their production processes. If these inputs are supplied by other businesses and sectors, it can be expected that these would also be affected.

6.11 In summary, the analysis of the impacts of behavioural change should consider the full range of public and private sector operations that may be affected by the change, including direct, indirect, demand and supply relationships. A full scoping exercise to identify all possible effects would require careful research and consultation with various stakeholders and affected parties. However, an initial inventory of impacts for each of the twelve behavioural goals has been carried out and is presented in the table in Annex G.

6.12 **Tier three impacts** are those which are linked to high level changes in the macro-economy. These effects are discussed in a separate category because their relationship with behavioural change is not immediately obvious, and it is generally difficult to estimate either qualitatively or quantitatively, without sophisticated forms of analysis. These are discussed in the next section.

6.13 Tier three impacts are perhaps most important when we consider the collective impact of a range of behavioural changes occurring at the same time. This is true where each individual type of behavioural change may not make much

difference to macroeconomic indicators, such as the growth rate, though might when considered with others. This is of key interest if simultaneous implementation of behavioural change policies instruments is to take place.

6.14 To demonstrate this, consider the group of energy behaviours: ***"install insulation"***, ***"buy energy efficient products"***, ***"better energy management in the home"*** and ***"install domestic micro-generation"***. They each have an effect on energy consumption, and the joint effect may be strong enough to warrant changes to energy generation infrastructure, but may not do so individually. There may also be further indirect effects. For example, two of the four imply physical changes to residential properties, which may also have a subsequent effect on the housing market.

Measuring Economy-Wide Effects

6.15 This section presents possible approaches to measuring tier two and three impacts: partial equilibrium analysis and forms of the general equilibrium method.

6.16 **Partial equilibrium analysis** tends to focus directly on the modelling of supply and demand conditions that occur in the markets and sectors directly affected by behavioural change, though sometimes it is broadened to include other markets that are indirectly affected. In order to estimate impacts, a counterfactual approach that compares a baseline scenario without intervention against a scenario with intervention is adopted. Regulatory impact assessment within central government typically uses a form of partial equilibrium modelling.

6.17 The approach is most suited to the analysis of individual behavioural goals and the estimation of tier two impacts. Only in rare cases can inferences about the effects on the tier three impacts be drawn.

6.18 **General equilibrium models** can potentially model both tier two and three effects. The first approach described here is ***Input-Output (I-O) Modelling***. In modern economic systems, each agent exists as both a supplier and a consumer of inputs. For example, mining companies consume mining equipment and labour and supply extracted material down-stream. The steel industry consumes iron ore and energy to produce steel, purchasing units of labour and other components along the way. Consumers purchase final products and services, producing waste and recyclables. Recyclables are sent to the reprocessing plants before being sold to manufacturers as an input, and so on and so forth. I-O models use these

relationships to investigate how changes in demand for certain goods (e.g. a fall in the demand for agricultural produce if we waste less food) trace through to other sectors of the economy. The primary output of I-O modelling is an estimate of the multiplier effect. The multiplier reflects the fact that a unit increase in demand can increase total output across the economy by more than one unit. The Office for National Statistics periodically provides I-O data tables for this form of analysis, most recently in 2006.

6.19 An advantage of I-O modelling is that several different changes in consumption can be investigated at once, and it is thus suitable for investigating the joint effects of behavioural change on the economy. Aside from the multiplier effect, which can be related to economic growth, I-O models can be extended to investigate other changes, for example, those in employment and total energy use. Another possibility is the use of environmentally-extended I-O models, which combine data tables with pollutant emission factors to predict the effects of behavioural change on the environment.

6.20 A disadvantage of I-O modelling is that it necessarily assumes that the parameters describing the relationship between various agents remain constant. In reality, relationships between suppliers and producers evolve to reflect new technologies, production patterns and attitudes. Therefore, this assumption can be considered as unrepresentative for the analysis of behavioural change, as increasing uptake implies that attitudes to consumption and production change. For the same reason, I-O modelling is particularly unsuited to predicting changes over time.

6.21 ***Computable General Equilibrium (CGE)*** modelling involves constructing a computer model of the economy to predict changes following different types of intervention. CGE models can take various forms, though like I-O modelling they are typically based on the links between suppliers and producers (both private and public sector). Several applied GE models have also been specifically designed to assess the overall economic impact of addressing greenhouse effects. Unlike I-O models, CGE models can potentially account for changing attitudes over time. However, a key drawback of CGE models is the time and cost associated with their construction.

6.22 General equilibrium approaches are capable of capturing macro-economic effects more rigorously, though there is a trade-off against the data- and resource-intensive nature of such exercises. In the context of behavioural change, these approaches are likely to be invaluable in better representing the economic effects.

7 Conclusions

7.1 Whilst the project proved to be challenging and – due to data gaps – the subsequent results should only be seen as indicative, it has proved to be a valuable exercise. As far as the authors are aware, this is the first attempt at quantifying the costs and benefits associated with such a wide range of pro-environmental behavioural changes. In so doing, it has identified the data that is available to undertake a cost effectiveness analysis (i.e. the estimation of marginal abatement costs).

7.2 The illustrative *concerted* uptake scenario developed for this project suggests that there is the potential for around 120 million tonnes of CO_2e ($MtCO_2e$) emissions savings in England between 2007 and 2020 (using the actual take-up of these behaviours in 2007 as the base year starting point to assess how the take-up of the behaviours could increase to 2020; see Table 7-1). However, it is important to note

Table 7-1: Indicative Potential for Cumulative Savings in CO_2e Emissions (between 2007 and 2020) from adopting the pro-environmental behaviours, in addition to existing policies[39]

	Emissions savings within EU ETS cap (traded sector)	**Emissions reductions not covered by EU ETS (non-traded sector)**	**Emissions reduction in the covered and not covered by EU ETS**
Concerted Scenario	65 $MtCO_2e$ *(40 – 75 $MtCO_2e$)**	60 $MtCO_2e$ *(40 -70 $MtCO_2e$)**	**120 $MtCO_2e$** ***(80 - 140 $MtCO_2e$)****
Far reaching Scenario	100 $MtCO_2e$ *(55 - 130 $MtCO_2e$)**	180 $MtCO_2e$ *(95 - 230 $MtCO_2e$)**	**280 $MtCO_2e$** ***(150 - 355 $MtCO_2e$)****
Total (concerted + far reaching)	**165 $MtCO_2e$** ***(90 - 200 $MtCO_2e$)****	**235 $MtCO_2e$** ***(135 -300 $MtCO_2e$)****	**400 $MtCO_2e$** ***(230 - 495 $MtCO_2e$)****

*Note that the figures in brackets are indicative ranges within which the central estimate might vary. These are based on an assessment if the potential impacts of the caveats on the central estimates. They should not be taken to represent statistical significance, for example.

[39] Numbers do not add up in all cases due to rounding.

that this figure is only a central estimate, as there are a number of caveats (see Box 1-1) that might increase or reduce this central figure. For example, we estimate that the potential cumulative reduction between 2007 and 2020 under the *concerted* scenario might be between 80 and 140 $MtCO_2e$ (the range expressed in brackets in Table 7-1) around the central figure of 120 $MtCO_2e$.

7.3 An additional 280 $MtCO_2e$ emissions (potentially ranging from 150 to 355 $MtCO_2e$) could be delivered in England under the illustrative *far reaching* scenario. In other words, there is the potential to deliver a total additional CO_2e emissions saving of 400 $MtCO_2e$ between 2007 and 2020 (ranging from 230 to 495 $MtCO_2e$) if all behaviours delivered as assumed under the illustrative *concerted* and *far reaching* scenarios (to the levels indicated in Table 2-1). Around 80% of the additional potential reduction under the illustrative *concerted* and *far reaching* scenarios that could be delivered by the behaviours is delivered by the behaviours for which we have ***lower levels of confidence*** in the results (see Figure 4-1). Under the illustrative *concerted* scenario, around 60 $MtCO_2e$ of emissions savings would occur in the non-traded sectors, while under the *far reaching* scenario 180 $MtCO_2e$ of the additional savings would take place in this sector. Hence, we have estimated that there is the potential to deliver around 235 $MtCO_2e$ reductions in non-traded sectors (see Table 7-1), which is equivalent to around 3.3% of the UK's annual emissions of CO_2.

7.4 The savings delivered under the illustrative *concerted* and *far reaching* scenarios are additional as they would be on top of the emissions savings delivered by planned policies (if these deliver as anticipated), which would amount to nearly 160 $MtCO_2e$ abatement (of which more than half would be achieved in the non-traded sectors; see Figure 3-4 in Box 3-5 and Figure 4-2 in Box 4-2). Two-thirds of these savings would be delivered by the behaviours for which we have ***most confidence (***see also Figure 4-1).

7.5 Table 7-2 shows the **emissions reductions for 2020 *only*** that would be delivered under the illustrative *concerted* and *far reaching* scenarios, i.e. the CO_2e savings that would occur in 2020 compared to the baseline as a result of the attainment of the up-takes assumed under these scenarios (as indicated in Table 2-1). This shows that, in total, CO_2e emissions in 2020 in England might be around 50 $MtCO_2e$ (ranging from 30 to 60 $MtCO_2e$), with twice as much of the emissions reductions being delivered by the illustrative *far reaching* scenario. Under the illustrative *concerted* scenario, the savings occur more or less equally in the traded

and non-traded sectors, while under the illustrative *far reaching* scenario more potential reductions could occur in the non-traded sectors than in the traded sector.

Table 7-2: Indicative Potential for Savings for 2020 in CO_2e Emissions from adopting the pro-environmental behaviours, in addition to existing policies[40]

	Emissions savings within EU ETS cap (traded sector)	**Emissions reductions not covered by EU ETS (non-traded sector)**	**Emissions reduction in the covered and not covered by EU ETS**
Concerted Scenario	10 $MtCO_2e$ *(5 – 10 $MtCO_2e$)**	10 $MtCO_2e$ *(5 -10 $MtCO_2e$)**	**15 $MtCO_2e$** ***(10 - 15 $MtCO_2e$)****
Far reaching Scenario	15 $MtCO_2e$ *(5 - 15 $MtCO_2e$)**	25 $MtCO_2e$ *(10 - 30 $MtCO_2e$)**	**35 $MtCO_2e$** ***(20 - 45 $MtCO_2e$)****
Total (concerted + far reaching)	**25 $MtCO_2e$** ***(10 - 25 $MtCO_2e$)****	**30 $MtCO_2e$** ***(15 -35 $MtCO_2e$)****	**50 $MtCO_2e$** ***(30 - 60 $MtCO_2e$)****

*Note that the figures in brackets are indicative ranges within which the central estimate might vary. These are based on an assessment if the potential impacts of the caveats on the central estimates. They should not be taken to represent statistical significance, for example.

7.6 Potential emissions savings that occur in the traded sector are contributing to the delivery of the emissions reductions required from the electricity generation industry under the EU Emissions Trading Scheme and help to meet the EU ETS cap; often these savings would be highly cost-effective compared to other actions. These reductions would be beneficial in that they increase the revenue that the UK receives from the sale of EU ETS allowances and also reduce the emissions baseline of the industry, thus enabling, in the longer-term, stricter emissions targets.

7.7 It is important to note that not all of the potential CO_2e emissions reductions – either under the baseline or the illustrative scenarios – will necessarily be in the UK. This is because CO_2e saved that is embedded, say in waste that is recycled, could lead to reductions in CO_2e in other countries, in this example by a reduction in the CO_2e emitted in the process of extracting natural resources.

7.8 If an individual household were to adopt the actions that might result from behavioural change, we estimate that there is the potential for an average household

[40] Numbers do not add up in all cases due to rounding.

to save more than £2,100 a year (see Figure 4-3). Only just over £300 of these savings is from the adoption of the energy behaviours in which there was more confidence; the remainder comes from the adoption of the other eight quantified behaviours, so there is a fair degree of uncertainty associated with this figure. Furthermore, the potential benefit for a particular household will depend on a range of factors, such as the size of the dwelling and the usage of the various products and services. Additionally, this figure assumes that the household adopts all the actions listed in Table 2-1 that are possible (i.e. those that are neither mutually exclusive nor overlapping) and that it was not previously undertaking any of these. The potential savings result from lower food bills, lower transport fuel bills, lower household energy bills and lower water bills (for those households that are metered for water).

7.9 **In spite of the above, the findings of this project can, and should, only be treated as indicative for a number of reasons.**

7.10 First, the scope of the project, and the timescale in which it was done, facilitated only a relatively simple modelling exercise and necessitated a significant number of high level assumptions. As far as possible, data was taken from authoritative sources and made consistent across each of the behaviours. However, the sources from which the data was taken had been commissioned for different purposes, so it is inevitable that different assumptions underlie these. In some cases, little, or conflicting, evidence was all that could be identified.

7.11 Second, some of the behaviours are relatively vague and the actions that might result from their adoption are not explicit in Defra (2008). Hence, it was necessary to identify these actions in order that the associated costs, benefits and abatement potential could be estimated. In many cases, it was not possible to identify a comprehensive set of actions, so a subset of the possible actions that could contribute to each of the behaviours was considered in the assessment. Consequently, the results are necessarily partial.

7.12 Additionally, some of the headline behaviour goals would benefit from rephrasing. For example, adopting the ***"avoid unnecessary flights (short haul)"*** behaviour would clearly be beneficial for the environment, if 'unnecessary' is interpreted as flights that bring no other social or economic benefit. However, for the researcher trying to estimate the impacts of adopting this headline behaviour goal, it is difficult to identify what the term 'unnecessary' might mean in practice; hence, this behaviour was not included in the quantified assessment undertaken as part of this

project. A more specific definition, for future analysis, could be ***"making smarter flight choices"***[41]. Other headline behaviour goals would also potentially benefit from rephrasing if they are to be used as a means of communication to the wider public. For example, ***"more responsible water usage"*** sounds judgemental – ***"better water management in the home"***, reflecting the wording of the ***"better energy management in the home"*** behaviour, might be better. Additionally, the ***"use more low energy consuming vehicles"*** is not as clear as it might be – ***"buy only A- or B-rated cars"*** might be a clearer option. Such issues might be considered as part of future reviews.

7.13 Third, the **illustrative uptake scenarios represent plausible levels of behavioural change and are based on expert judgement**. Even though these were informed by Defra's survey of people's ability and indicated willingness to act, they should not therefore be taken as projections or evidence of what will happen. Linked to this is the difficulty in identifying a consistent baseline for all of the actions that might result from the adoption of the headline behaviour goals. While it was possible to link four of the headline behaviour goals to the Energy White Paper, thus providing some degree of consistency, it was not possible to link the other eight behaviours in this way. Hence, assumptions of the uptake of the various actions in the absence of additional policies had to be made.

7.14 Fourth, the data that was used represents 'average' or 'typical' costs for a household. For many of the behaviours, the costs and benefits experienced by different households are likely to vary – sometimes significantly – depending on a range of factors including the size, type, location and state of the dwelling, or the way in which a product is used. Hence, certain actions associated with the behaviours will be more appropriate for some households than others, and individuals would be expected to adopt those actions that best suit their needs and lifestyle. This may result in much higher benefits for these households than the averages that have been estimated. For example, under the ***"use more low energy consuming vehicles"*** behaviour the cost of purchasing a more expensive, yet potentially more efficient car, e.g. a hybrid, would be off-set more quickly by households that use their cars more than average. These households will potentially save more by using such vehicles, and therefore are likely to be the early adopters of such technology, whereas a household with (below) average car use might not. Subsequently, as a

[41] Where viable transport alternatives exist.

result of this early take-up, economies of scale may be realised in the production of such systems leading to lower unit costs for later potential purchasers.

7.15 Fifth, there are still some potentially influential benefits and costs, in terms of their economic value, that are not included in the analysis. While the benefits of CO_2e savings are included in the economic assessments, **other environmental, social and health costs and benefits** are not. As it was not possible within the scope of this project to quantify such impacts, existing sources were sought. However, the sources that were identified provided data for only a few of the behaviours. Consequently, for the sake of consistency, it was agreed that no estimates of environmental, health and social benefits should be included in the estimation of the benefits and costs that are presented in Sections 3 and 0.

7.16 Sixth, no attempt was made to **quantify the barriers to uptake**. As was discussed, some of the major costs left unquantified are those relating to the additional time required, 'hassle' incurred and 'sacrifice of service' – all major obstacles to changing behaviours. Additional time is required before many of the actions can be adopted, e.g. to research different options for reducing car travel or waiting for insulation to be installed. 'Hassle' encompasses a range of attitudinal, emotional and lifestyle barriers, for example, the effort required in remembering to turn off a light when leaving a room or that required in planning meals better. 'Sacrifice of service' refers to instances where an alternative behaviour does not provide a similar level of service as the original behaviour, for example, an electric car is not as suitable for inter-urban travel as conventionally-fuelled cars.

7.17 The quantification and inclusion of these missing costs and benefits – either the benefits of improved environment and health or the costs associated with overcoming the various barriers to uptake – in the economic assessments of the headline behaviours have the potential to impact on the results of the respective assessments, as discussed in the relevant paragraphs of Sections 3 and 4. The impact of the inclusion of such costs and benefits has the potential to be significant. For example, studies suggest that there are potential health benefits from the adoption of some of the actions under the ***"adopt a low impact diet"*** behaviour. As there are potential health benefits from a number of other behaviours, e.g. from cycling and walking instead of using the car and from living in warmer homes, the fact that health benefits are not included potentially underestimates the benefits of several of these behaviours. On the other hand, many would perceive that the adoption of the diets under the ***"adopt a low impact diet"*** behaviour, all of which

require the consumption of less meat, would require some perceived sacrifice for some people. This sacrifice will be in the context of deeply entrenched food culture for many and the perceived increased hassle associated with cooking vegetarian food of equivalent flavour. The inclusion of this perceived sacrifice in the cost estimates has the potential to significantly reduce the relative cost-effectiveness of the behaviour. Hence, the ultimate impact on the results for the ***"adopt a low impact diet"*** behaviour would depend on the balance of all the additional costs and benefits. A similar discussion could be set out with respect to many of the behaviours.

7.18 Seventh, some of the **behaviours are closely linked, so the potential benefits of one might influence the impact of another**. While care was taken to take account of any subsequent overlaps, it is likely that some benefits have still been overstated. Conversely, the potential for the adoption of one of the behaviours to catalyse the uptake of others has not been captured within the scenarios.

7.19 Eighth, the **estimation of the costs and benefits** of household behavioural change – Objective 1 of the project – **focused only on first order effects at the household level**. In other words, only direct, financial costs and benefits to households were estimated to arrive at the results presented in Sections 3 and 4. Objectives 2 and 3 of the project, which are presented in Sections 5 and 6, set out methods for evaluating the potential indirect effects of household behavioural change and any wider economic impacts, respectively. The work undertaken for these two objectives was conceptual in nature and together the two objectives were a relatively small part of the project. However, in determining the eventual impact, and therefore costs, benefits and CO_2e abatement potential associated with any of the behaviours, their consideration is potentially important.

7.20 Section 5 focused on the indirect effects that might result if a household were to save money as a result of changing its behaviour. If a household were to save money, this would either be spent or saved on other goods or services. If any money saved from better energy management in the home was spent on travelling more by car, for example, the net costs, benefits and CO_2e abatement potential, would be far from clear. The additional emissions from using the car more would reduce the benefits of, and could even cancel out, the reductions achieved by better energy management at home.

7.21 In Table 5-1, an example was presented of the potential impact of households

saving money on the weekly food bill, which could, for example, be the result of adopting the ***"adopt a low impact diet"*** behaviour. Although the results are partly based on an old dataset, the figures from Approach 2 (which is considered to be the more accurate) suggest that expenditure on both transport/communications and fuel[42] might increase by around 4% if the food bill was reduced by around 35%. This demonstrates the importance of recognising and modelling these indirect effects, as it suggests that the benefits and CO_2e abatement potential of many of the behaviours would probably be less than the numbers presented in Sections 3 and 0.

7.22 As has been discussed, the results presented in this report clearly have their limitations. Should Defra wish to gain a greater understanding of the true costs, benefits and CO_2e abatement potential associated with behavioural change, **we suggest that there is a need for further research**, such as:

- A number of the behaviours considered in this report would benefit from a more comprehensive analysis of their benefits and costs in relation to delivering environmental improvements, particularly, but not limited to, reducing greenhouse gas emissions. The non-energy behaviours would especially benefit from such research.
- Research on the further quantification of the benefits (and costs) of behavioural changes – particularly in relation to health, but also the environment – that are not reflected in market prices would be useful in order that such benefits and costs can be included in the economic assessments of behavioural change.
- An assessment of the importance of costs, such as those related to 'hassle' and 'sacrifice of service', through original empirical research would help to ascertain the extent to which these are interpreted and valued differentially by different population segments. More generally, ongoing work is needed to monitor developing attitudes and behaviours in this area across different segments of society. This would be intended to develop a more complex understanding of the responses of households under changing external conditions such as state of the economy and new technological options becoming available.
- Work to consider how the variation in households affects the outputs of this type of modelling exercise – for example, the variability in household size, dwelling size, construction and location.
- A longer-term, larger project to assess the benefits, costs and CO_2e abatement potential of behavioural change would be beneficial. This would enable a more comprehensive consideration of the potential impacts of behavioural change.

[42] Transport fuels are included in the "transport/communications" category; "fuels" covers non-transport fuels.

- The creation of a database into which information on behavioural change could be collected would facilitate the ongoing policy work in this area.
- The development of a model to estimate the impacts of the indirect effects of behavioural change, in terms of how households might spend any income saved (as described conceptually in Objective 2) is also important.
- Consideration of how behavioural change policies might influence secondary-spend behaviour, or at least the degree to which underlying attitudes and preferences are changed by different policy mechanisms and therefore the optimum policy approach in particular behavioural areas.
- Consideration of how behaviour changes might interrelate; either by catalysing between the goals or the impact on the population if one segment takes the lead.
- A full scoping exercise to identify all possible effects of behavioural change on the wider economy would be beneficial, which should involve consultation with various stakeholders and affected parties. This would build on Annex G, which was developed under Objective 3.
- The development of general equilibrium approaches to capture the wider macro-economic effects of behavioural change could be important in better representing these economic effects (see paragraph 6.22).

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Behaviour specific information

Install insulation products

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While the two reports outlined above formed the basis of the evidence used for the assessment, other sources that considered, but ultimately rejected, include:

- Energy Saving Trust Website: http://www.energysavingtrust.org.uk
- BRE, Reducing carbon emissions from the UK housing stock, 2005.
- Defra, Potential carbon savings from energy efficiency and microgeneration appliances installed in the domestic sector over the period of 2011 – 2020.
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Buy energy efficient products

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