



Focus on behaviour change – reducing energy demand in homes





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in homes

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KEY IMPLICATIONS

Introduction

The key points given below are for policy makers and for intermediaries (e.g. local authorities, third sector groups or energy advisers) who are developing campaigns or other interventions with householders to encourage them to invest in technologies or alter the way they use energy.¹

1. The means, motive and opportunity for change need to, in combination, overcome whatever barriers exist – whether they arise from finance, time, habits, routines, established lifestyle choices, personal image or ignorance.
 - The *means* is the technology (a characteristic of the building fabric or services) or behaviour that will lead to reduced carbon dioxide (CO₂) emissions.
 - The *motive* is the reason why households will want to make the change.
 - The *opportunity* is the resource (e.g. time, space or money) to make the change.
2. Intervention should focus on specific behaviours, not attitudes, knowledge, or energy-related behaviour in general. Behaviours range from everyday habits to complex and expensive one-off investments – see Annex A.

Means

3. There are various options for combinations and sequencing of individual behaviours; the elements should be phased appropriately to manage the effectiveness of measures, their cost and the risk of unwelcome side effects.
4. To encourage change, householders need sufficient information (as summarised in Annex A) about each means to make informed choices. Householders can also benefit from:
 - direct feedback to identify where excessive energy is being used and to monitor the success of attempts to reduce use (e.g. using smart meters, real time displays or billing that provides historic or peer group comparisons);
 - personal familiarity with the technology in question (e.g. through local ‘champions’, demonstration projects, placement of products in popular materials or furnishing stores, or regulatory changes for new homes).

5. Failure of improvement measures can result in demotivation and a reluctance to make further changes. It is, therefore, important to identify and manage risks so that householders can make changes with confidence.
6. Good technology can itself encourage change, e.g. controlling the heating will be promoted by clear, intuitive control systems.

Motive

7. For many households, climate change and CO₂ are not sufficient reasons for change: additional motives need to be found. Annex C describes a wide range of motives that could apply.
8. The various motives should not be used in a manipulative fashion: the aim should be to understand people and present options in a way that is in tune with their aims and values.
9. Householders, even if they are motivated directly by CO₂ savings, may not find CO₂ statistics meaningful unless they are put in a relevant context (e.g. average daily use per person, or an equivalent number of cups of water boiled).

Opportunity

10. Money (especially capital investment) is important but householders also need time and space to make the change. Conversely, they need to minimise lack of time and space (often called ‘hassle factor’) and loss of time and space (generally perceived as ‘disruption’).
 - A virtuous circle is created where savings on energy expenditure pay for a capital cost but this in itself is not always sufficient.
 - Time can include the time to work out what is worth doing, to manage a purchase and installation, and ‘transactional’ time (e.g. to obtain planning approval).
 - Space includes both having the space to make the change (e.g. to install a heat pump) and more complex considerations of preferences for use of space in the home.

¹ The detailed messages in this report are not in a style for presentation directly to the public – they are intended to assist intermediaries in developing programmes appropriate to their target audience.

11. Investment behaviour is complex and not fully predictable from payback period or net present value. However, there are several ways of helping householders, other than the obvious of making sure they are aware of any available grants, loans or other financial assistance, e.g.:

- providing information and services that make it quicker and easier for householders to understand options, take decisions and implement changes;
- aligning the motivation of different parties (e.g. landlord and tenant);
- clarity over the availability of financial incentives (now and in the future), so that the right time to act is clear and householders do not later regret acting when they did;
- clarity over how the mix of generation of power and heat will develop (e.g. fossil fuel vs renewable vs nuclear, and central vs community generation), since this will influence CO₂ savings and decisions on investment at household level.

12. Some changes would be most cost-effective if made on a street or neighbourhood level ('economies of scale') and/or where multiple installations are combined ('economies of scope') in a package of renovation and refurbishment.

Application

13. Intermediaries have massive potential for bringing about change in energy-related behaviour in the 'front line', because of the large number of people carrying the message and the nature of the access they have to households. Their value can be increased by having the right knowledge (hence training) and being trusted as reliable (e.g. by having access to information from an independent authoritative source).

14. Many groups are already involved:

- employers, family, friends and neighbours;
- in the energy sector itself (specifically or as part of a broader role – e.g. local authorities);
- in related areas (such as water efficiency or recycling);
- in groups that have another main focus and have already established access to homes and households (e.g. in the building trade – builders, plumbers, carpenters, decorators and electricians – and some major charities).

15. This is not just about information dissemination – it can include any or all of:

- understanding the motives of the particular household and being advocates for change;²
- analysing the context and identifying options (e.g. fabric, services provision, energy supply);
- assessing likely performance of each option (e.g. technical potential, technical risk, aesthetics) and of any combination of options;
- seeking appropriate solutions with respect to cost and benefit (particularly where there are potential economies of scope or scale);
- thinking beyond individuals to understand the social context and address communities and how they work together, in terms of:
 - means (some of which are illogical or impractical at the level of an individual household, e.g. district heating or small-scale renewable power generation);
 - motive (where changing social norms and developing mutual support for change can be powerful influences);
 - opportunity (through economies of scale and community-level grants).

² To achieve maximum impact, the market needs to be segmented by a wide range of household factors such as size, age, affluence and culture, dwelling factors and the wider community – not only attitude to climate change. This is a complex segmentation to handle centrally for a large population. Intermediaries can have the advantage of getting to know the person in front of them. It can help if they understand what segmentations exist and thus anticipate people's reactions, but it is not necessary for them to characterise the person before interacting.

WORKSHOP SUMMARY

Introduction

Behaviour change is not an optional aspect of reducing building-related emissions of carbon dioxide (CO₂) – it is at the heart of the process, so much so that it is often taken for granted. The technology to reduce CO₂ emissions may exist but it means nothing unless it is used, and used appropriately.

This summary report describes the output of an expert workshop that reviewed a theoretical framework, developed within Communities and Local Government (CLG), for how the behaviour of households can be changed to reduce energy use and emissions of CO₂.^{3,4} Associated with the framework is a set of information sheets – one for each household behaviour reviewed by the workshop. The framework is described in the main body of the report and the behaviour sheets are in Annex A.

The report is intended to:

- inform policy makers when they are considering interventions regarding domestic energy use and the potential for behaviour change;
- act as an information source to other parties (e.g. local authorities, third sector groups or energy advisers) who are developing campaigns or other interventions with householders to encourage them to invest in technologies or alter the way they use energy.

The report is not intended to be suitable for presentation directly to the public – it is intended to assist intermediaries in developing programmes appropriate to their target audience. The underlying ethos is that intermediaries can be more effective if they understand the range of personal values and motives that may underpin people's behaviour, and work with those values and motives instead of seeing them as barriers.

It is important to note that both understanding of behaviour change and the best technical solutions are evolving continuously, so the latest evidence should always be consulted when developing new information materials or other interventions. Also, many of the technical solutions are governed by regulations and standards (e.g. the Building Regulations), which may vary from time to time; it is essential always to check requirements before undertaking building work or installations in a dwelling.

³ "Focus on Behaviour Change", held in London on 23 October 2009. The workshop was initiated by CLG and managed by Arup. For a list of workshop participants, please see Annex B.

⁴ Reducing energy use and reducing CO₂ emissions are not wholly interchangeable aims but the former is one means of achieving the latter. This report refers to CO₂ where the aim is specifically reduction in CO₂ emissions and to energy where the mechanism of change is reduced energy use.

The framework

The framework is an outline theoretical structure based on establishing the means, motives and opportunities that are needed to instigate changes to behaviour.

- The *means* is the technology or behaviour that will lead to reduced CO₂ emissions.
- The *motive* is the reason why households will want to make the change.
- The *opportunity* is the resource (e.g. time, space or money) to make the change.

Each of the behaviour sheets in Annex A offers an "MMO Analysis" to explore the implications of these three components. The three, while distinct, are not independent: strong motive (at individual or society level) can lead to the creation, acceptance or discovery of means and opportunity; reliable means can increase (or allow recognition of) motive and make clear the opportunity; and opportunity can allow people to realise motive and create means.

Nevertheless, in promoting behaviour change, the three should always be clearly distinguished: not doing so will increase the risk of having an incomplete approach and, therefore, failure. For example, there is sometimes an implicit assumption that subsidising an energy-efficient upgrade in itself provides a motive. Unless the subsidy means that the purchaser is making a net saving over an alternative choice, the subsidy is not a motive – only an opportunity. There must also be some underlying reason why the purchaser wants to make the change.

The means, motive and opportunity need to be, in combination, sufficient to overcome whatever barriers exist – whether the barriers arise from finance, time, restrictive legal or contractual frameworks, personal inertia (e.g. habits, routines or established lifestyle choices), personal image or ignorance.

The behaviours

A focus on specific behaviours is in contrast to approaches that address attitudes or knowledge, or energy-related behaviour in general. The workshop considered only energy use in UK homes that arises from the building and its fixed services. For example, insulation, lighting and heating were included but refrigeration and cooking were not. Drying laundry was included, as provision of drying space is an aspect of the building itself. The distinction is not always clear-cut but the final list of behaviours reviewed is as follows.

- Switching off lights and appliances
- Energy efficient lighting

- Drying laundry
- Adaptive use of clothing
- Adaptive use of windows and ventilation (for keeping cool and for keeping warm)
- Heating controls: installation and use
- Space cooling
- Control and use of domestic hot water
- Maintenance of heating, cooling and ventilation systems
- Draughtproofing
- Solid wall insulation
- Cavity wall insulation
- Insulation of loft or roof
- Floor insulation
- Multiple glazing
- Installing a new boiler
- Installing a heat pump
- Solar thermal water heating
- Photovoltaic power generation

The behaviours range from simple everyday behaviours and habits (e.g. switching appliances off when not in use) to occasional behaviours (e.g. heating system maintenance) and more complex and expensive one-off investments such as installing (and then managing) a solar thermal hot water system. Some (e.g. using energy-efficient lighting) can change quickly; others (e.g. adaptive use of clothing) may require progressive changes in building technology and social norms.

This report generally considers behaviours independently. This is because intermediaries will have various options for combinations and sequencing, depending on the context in which they are working. The implications of this approach are considered further in the next chapter.

Means

The means is the technology (some characteristic of the fabric or services of a building) or behaviour that will lead to reduced CO₂ emissions. The main point is that, if the aim is to change behaviour, there needs to be clarity over exactly what householders are expected to do. In addition, they need sufficient information to make informed choices, based on knowledge of the options available to them, particularly where significant investments of money or time are required. The availability of reliable advisors, suppliers and installers is also an important aspect of the means.

The means, as defined here, is the change itself but it is also true that good technology can itself encourage change – the ‘affordances’ of technology. For example, controlling the heating will be promoted by clear, intuitive control systems

that are simple to use and retain time and temperature settings when switched off.

The behaviour sheets in Annex A provide a basic description of the means, the associated risks and need for information and explanation, for each individual behaviour. Explanation is a critical element: if potential users do not know that the means exists, that it works, and how to apply it, why should they change?

In addition to information specifically about the means, householders often benefit from direct feedback to identify where excessive energy is being used and to monitor whether attempts to reduce consumption are being successful. This approach recognises that energy is an ‘invisible commodity’ – people do not generally buy energy for its own sake, but rather they seek some outcome (e.g. keeping warm or toasting bread) and energy is simply the means to achieve the goal.

The common ‘feedback mechanism’ of the quarterly utility bill, often estimated, is too blunt an instrument for this purpose. Therefore, ongoing improvements (e.g. smart meters, real time displays and billing that provides historic or peer group comparisons) are to be welcomed; they make the energy more visible and therefore more likely to influence behaviour on a continuous basis, not just when the bill arrives. This report does not treat feedback as energy-saving in its own right but rather as a key facilitator of all the behaviours.

It is also clear that mere facts are not always persuasive and personal familiarity with (and confidence in) the technology in question is important. This can be achieved, for example, through local ‘champions’, demonstration projects, placement of products in popular materials or furnishing stores, or regulatory changes for new homes. It will be for intermediaries to decide how best to develop and use familiarity as part of their projects.

Without effective demonstration, unnecessary barriers to behaviour change can arise, for example, because earlier versions of a technology were known to be unsatisfactory (e.g. older solar thermal water heating systems and compact fluorescent lights) or because critical failures are given undue publicity (e.g. water tank bursts following inappropriate loft insulation).

Although risks (e.g. from poor choice or implementation of technology) are generally specific to each behaviour, some generic risks are noted here. While this report envisages starting with householders’ motives and identifying the behaviours that follow from those motives, uncontrolled opportunistic scheduling of works should be avoided. Whole-house solutions can be particularly effective but, where this is not feasible, there is value in at least phasing the elements

appropriately. Sequencing work can be critical to managing effectiveness, cost and the risk of unwelcome side effects.

Depending on the circumstances in each case, this might mean, for example:

- doing disruptive measures together (e.g. putting up scaffolding or lifting floorboards only once);
- making sure that later interventions do not undo some of the benefits of earlier ones (e.g. losing insulation from wall cavities when windows are replaced later);
- ensuring that combinations of changes will work effectively together;
- carrying out the most cost-effective measures first, so that the energy savings help to release the finance for other measures;
- identifying logical groups of measures, such as a new boiler plus heating controls plus a hot water storage vessel that is ready to be used with solar thermal water heating.

Apart from the direct risks, failure of improvement measures can result in demotivation and a reluctance to make further changes. It is, therefore, important to identify and manage risks so that householders can make changes with confidence.

The behaviour sheets provide estimates of potential CO₂ emission savings.⁵ These should be seen as general indications and not a precise expectation or target, especially as the CO₂ per kW hour is not fixed but will vary with energy supplier and over time. These savings estimates are provided mainly for the benefit of intermediaries in helping households towards balanced decisions on making changes. The householders themselves, even if they are motivated directly by CO₂ savings, may not find CO₂ statistics meaningful unless they are put in a relevant context (e.g. average daily use per person, or an equivalent number of cups of water boiled). It should also be kept in mind that even small savings are worthwhile, especially where they can be replicated in a large number of dwellings – at national level or within the scope of a particular project.

Motive

The motive is the reason why households will want to make the change. Climate change and CO₂ may be the motives for this report, and for intermediaries to take action, but for many households they are not sufficient motive for change, and sometimes not a motive at all (or even demotivating as a subject for discussion). This may change over time but, at present,

additional motives need to be found. This report identifies some possible motives that could apply to some householders and some behaviours. The intermediary's role is to determine which motives are relevant to the case in question. This is not intended to be done in a manipulative fashion but to understand people and operate in tune with their aims and values.

The list of motives evolved during the workshop and in producing this report. There is not a single way of structuring the list and it should not be seen as definitive, final or an order of priority. With these caveats, the list is as follows (Annex C gives a more detailed explanation of these categories of motive).

- (a) Save the planet.
 - Reduce CO₂ emissions to avoid dangerous climate change.
 - Reduce global pollution and depletion of natural resources.
- (b) Save the country.
 - Achieve security of energy supply and national self-sufficiency.
 - Avoid environmental degradation in other countries leading to wars and mass movement of people – some to the UK.
- (c) Save my household.
 - Avoid loss of land, severe weather, floods and property becoming uninsurable and losing value.
 - Maintain local security of energy supply.
- (d) Save (or make) money.
 - Save money on fuel bills.
 - Make money by selling electricity.
 - Increase property value.
 - Spend money on something else, e.g. heating or non-energy needs.
- (e) Avoid waste.
 - Reduce energy wastage.
 - Reduce wastage of other resources.
- (f) Wellbeing.
 - Be comfortable and healthy.
 - Increase productivity – in employment or domestic work.
 - Get safer appliances, building fabric or lifestyle.
 - Enhance security (or perceived security).
- (g) Improve aesthetics.
 - Improve the look (or feel) of my home or something within it.

⁵ All CO₂ figures are taken from the Energy Saving Trust website unless otherwise referenced.

- (h) Feel good about yourself.
- Doing something for the wider good.
 - Taking pride in the neighbourhood, city or country.
 - Developing a technical competence.
 - Teaching the next generation.
 - Fulfilling a desire for self-sufficiency or personal control.
 - Becoming more in tune with nature.
 - Gaining social acceptance or avoiding social rejection.
 - Promoting a positive image of the person, household or organisation.
 - Association with role models.
- (i) Make my life easier.
- Reduce the burden of an activity or task.

Climate change may not be the household's principal motive, and other motives can also be valid, but ideally the household's decision process should create sufficient interest in climate change to avoid the 'rebound' effect whereby money saved on energy costs is spent on more carbon-intensive activities (e.g. air travel).

Opportunity

The opportunity is the resource (e.g. time, space or money) to make the change. The focus is often on money (especially capital investment) but it is also important that householders have time and space to make the change. They will also want to minimise lack of time and space (often called 'hassle factor') and loss of time and space (generally perceived as 'disruption').

- Money may be the household's own or a landlord's, or come in the form of direct subsidy, tax relief, loan or discount. A virtuous circle is created where savings on energy expenditure pay for a capital cost but this in itself is not always sufficient, even if the capital cost is mitigated – perhaps because of the other key element of opportunity, time.
- Time includes the time to work out what is worth doing (e.g. in economic or environmental terms) or to manage a purchase and installation (even if this means just being at home during installation). In some cases, there are also 'transactional' barriers such as planning approval. And time can also mean money. This barrier can be reduced by making it easier to take and implement decisions: the means and opportunity need to be pointed out in a simple and convincing way.
- Space includes both having the space to make the change (e.g. to install a heat pump) and more complex considerations of preferences for use of space (e.g. open plan vs rooms with

doors that can be closed, having an office at home, or using the loft for storage).

Opportunity is also likely to depend on creating aligned or complementing motivation among different parties. The classic situation, for example, is the landlord who is responsible for the building and the tenant who would benefit from improvements (in comfort and/or fuel bills); common opportunity is the key to unlocking resources here.

A specific case of this need for common action can be called 'permission'. This can mean, for example, people knowing that it is OK to match their dress to the thermal conditions or to turn off TVs and computer monitors that have been left on by others. But there is a more subtle aspect to this too, in giving people the social context in which they can change behaviour without appearing mad, broke or mean.

Opportunity also depends on a political and social context that cannot entirely be predicted: relevant considerations are the availability of grants or other financial incentives (now and in the future) and the mix of generation of power and heat (e.g. fossil fuel vs renewable vs nuclear, and central vs community generation). These will influence payback times and CO₂ savings and therefore people's thinking on if and when to act. Also, if someone invests in an energy saving measure, then fuel prices go up, it may not be clear to them that they have made cost savings on their bills; hence further investment may become less likely.

The amount of time that people spend in the home may also shift their perception of values. So, for example, if someone starts spending more time in the home (e.g. after having a baby or retiring), comfort in the home may acquire a higher value.

Therefore, investment behaviour is complex and not fully predictable from payback period or net present value. However, there are several ways of helping householders to realise the opportunity, other than the obvious of making sure they are aware of any available grants, loans or other financial assistance.

Some changes would generally be most cost-effective if installed on a street or neighbourhood scale ('economies of scale') and/or where multiple installations are combined ('economies of scope'). For example, points at which renovation and refurbishment are taking place provide an opportunity to engage and inform householders about a broader range of opportunities, and for the householder to combine measures in a way that reduces costs.

Identifying such occasions may depend on intermediaries who are in the home to carry out the work (e.g. builders, plumbers, carpenters, decorators and electricians). If they are to have

influence, they need to have the right knowledge (hence training) and to be trusted as reliable and not just out to make more money. Trust can be increased by providing them with information from an independent authoritative source.

Other intermediaries can also play this role, for example family, friends and neighbours. For some behaviours, there is also the potential to learn in another context (e.g. switching off lights at work).

Application

As already noted, intermediaries play a critical role in bringing about change in energy-related behaviour. This is not just about information dissemination; intermediaries can, for example:

- understand the motives of the particular household and be advocates for change;
- analyse the context and identify options (e.g. fabric, services provision, energy supply);
- assess likely performance of each option (e.g. technical potential, technical risk, aesthetics) and of any combination of options;
- seek appropriate solutions with respect to cost and benefit.

Enabling intermediaries to become more effectively involved as the 'front line' has massive potential, based on the number of people carrying the message and the nature of the access they have to households. A follow-up workshop with representatives of this sector may be useful to begin to scope an approach.

But this is not a 'standing start' situation. Many groups are already involved – in the energy sector itself (specifically or as part of a broader role – e.g. local authorities), in related areas (such as water efficiency or recycling) and increasingly in groups that have another main focus. This latter category ranges from individuals in the building trade (as noted above) to major charities; the connection is that they have already established access to homes and households in a context other than energy. This can give them a position of greater trust with householders because they are not seen as "just saying what you would expect them to say" about energy savings.

Such intermediaries can also find it easier to understand the household in a more rounded way, not just as an energy-consuming unit – recognising that people have a range of concerns and their behaviour responds to a range of factors. This demands an appreciation of differences arising from household factors such as size, age, affluence and culture, dwelling factors and the wider community. In other words, the means, motives and opportunities will vary widely with a

number of factors related to buildings and their users.

To achieve maximum impact, the market needs to be segmented, for example by:

- building type, characteristics and whether it is new or facing minor/major refurbishment;
- location (e.g. urban/rural and climatic) – buildings do not exist in isolation and their location affects potential and actual energy efficiency, occupant behaviour and options for renewable energy;
- occupant demographic (number, age, culture and nationality) and, where applicable, the climate and typical building design/use in the household's country/region of origin;
- current level of knowledge of how to use a building of the type occupied or managed;
- resources of the occupant/manager/owner;
- current attitude to reducing CO₂ emissions, the environment more generally and competing priorities.

This is a complex segmentation to handle centrally for a large population. Intermediaries can have the advantage of getting to know the person in front of them. It can help if they understand what segmentations exist and thus anticipate people's reactions, but it is not necessary for them to characterise the person before interacting.

The focus of this report is CO₂ emissions but, as appropriate to the context, intermediaries will need to minimise negative consequences of behaviour change on other greenhouse gases emissions (e.g. of methane), other types of environmental impact (e.g. local air pollution or loss of land to small-scale renewable power plant) and other impacts altogether (e.g. financial or health impacts). This may require consultation with experts in the relevant area.

This report has generally been set in the context of influencing individuals and households but they do not act in isolation – action will partly be defined by social context. Some intermediaries are also in a position to take this up a level and address communities and how they work together. A community is more than a collection of individuals and it has great potential in terms of:

- means (some of which are illogical or impractical at the level of an individual household, e.g. district heating or small-scale renewable power generation);
- motive (where changing social norms and developing mutual support for change can be powerful influences);
- opportunity (through economies of scale and community-level grants).

Annex A. The behaviours

Switching off lights and appliances

Energy efficient lighting

Drying laundry

Adaptive use of clothing

Adaptive use of windows and ventilation (for keeping cool and for keeping warm)

Heating controls: installation and use

Space cooling

Control and use of domestic hot water

Maintenance of heating, cooling and ventilation systems

Draughtproofing

Solid wall insulation

Cavity wall insulation

Insulation of loft or roof

Floor insulation

Multiple glazing

Installing a new boiler

Installing a heat pump

Solar thermal water heating

Photovoltaic power generation

Switching off lights and appliances

Summary of change

Energy demand for the running of appliances and lights would be reduced if they were switched off when not in use, overnight and during periods when occupants are away from the home, e.g. on holiday.

Potential CO₂ benefit

The benefit is highly variable, depending on current behaviour and the power drain of appliances left on. In the extreme, for example, leaving incandescent lights on around the house, and keeping televisions and PCs on when nobody is watching/using them, could easily amount to a tonne of CO₂ per year.

MMO Analysis

Means

The means would simply be to switch off lights and appliances when they are not in use, especially overnight and when occupants are away from the building for a prolonged period, to reduce energy use. This change should include the following.

- Switch off lights when they are not needed (principally when the room is unoccupied or daylight is adequate).
- Conversely, choose a location with good daylight for reading, writing, etc. so that lights are not needed. Or use a low wattage light close to the task, rather than a higher wattage light on the ceiling or wall.
- Switch off televisions, videos, DVD players, stereos, etc. when not in use (i.e. switch off the power, rather than setting to standby mode).
- Plug home electronics, such as TVs and DVD players into power strips and then turn these power strips off when not in use.
- Turn off computers, servers and monitors when not in use.
- Choose appliances that can default to off when not in use and set them to that default (or at least to a low-energy setting, such as PCs dropping to 'stand-by' or 'hibernate' mode).
- Unplug battery chargers when the batteries are fully charged or the chargers are not in use.

In support of this means, key points should be addressed that encourage people to start actively thinking about switching off. There needs to be a change in attitudes and habits so that people begin to ask themselves whether something really needs to be switched on (i.e. to only switch on the lights

and appliances they are needed) or could be switched off (i.e. whether they need to be using energy with that appliance at this very moment).

Technology can support the behaviour change in a number of ways, which would need to be considered particularly when replacing appliances.

- Depending on the appliance, it may be easier and/or save more energy to unplug an appliance or switch off the socket. Hence, switched sockets make the action easier and therefore more likely to be carried out.
- Specialised socket adapters are available for computers, which switch off peripherals when the computer is shut down.
- Switches on appliances themselves should be obvious and easily accessible – preferably on the front of the appliance unless safety dictates otherwise.
- Willingness to turn appliances off will be greater if any settings (e.g. clocks, timers, preferences) are saved and restored when the appliance is switched back on. While this requires batteries, the power required by the batteries will generally be offset by the power saved by not having the appliance switched on unnecessarily.
- A 'kill switch' to turn off all lights and/or sockets may also encourage some users. This needs to be located appropriately (e.g. near the front door).
- Light switches and sockets should be positioned to make them easy to reach (especially for people whose mobility is restricted through age or disability). This is covered in Part M of the Building Regulations for new build, but is unlikely to have been altered in the majority of existing homes.

There are no significant risks involved except possibly in accessing awkwardly positioned switches.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All three motives apply but the order of relevance can be confusing. There is not likely to be a very strong mental association between turning appliances off and saving the planet but it is at the aggregate level that the benefits are seen: the power drain of appliances on standby is small and may be 'below the radar' of individual households,

and yet is a large avoidable demand at the level of countries, continents or the planet.

Therefore, this means does require an attitude directed much more on saving the country and not oneself as it will be the cumulative difference of multiple households making the change that will generate the desired effect.

(d) Save (or make) money

Money saving is likely to be marginal in many households (with exceptions, depending on current behaviour) and yet can still be prominent in people's thinking. This creates a positive pressure towards saving energy but with a risk that more important measures are overlooked.

(e) Avoid waste

As saving money may not always be a strong motivation, not wasting energy might have more impact, particularly among higher income groups where money is less of an issue, and if messages concentrate on the cumulative benefit of all households changing.

(f) Wellbeing: be healthy, comfortable, safe and productive

This motive may negatively impact this behaviour, because leaving lights on gives a perception of security and comfort. Security may be a particular issue in areas that are perceived as unsafe.

There is also the possibility of arguments in the household as some people prefer daylight and will tolerate very low light levels with the lights off while others constantly turn lights on. In a household this can lead to conflict and logically the most likely outcome is that the lights-on state will prevail.

Where appliances (such as microwaves with digital displays and VCRs), when switched off and back on, require their clock displays to be reset, this is likely to be viewed as a further inconvenience.

This change therefore needs to become a habit like turning off the oven when (or just before) food has finished cooking.

Safety is not likely to be of any major significance, other than reducing the risk of fires from appliances (especially those with exposed hot

elements, such as electric fires or even hair-straighteners). Lightning strike is also a risk where appliances are left plugged in, even if switched off. If appliances have to be kept plugged in, this risk can be mitigated by plugging in to a suitable protective device with a double-pole isolation.

(g) Improve aesthetics

This is not likely to be a motivating factor for this behaviour.

(h) Feel good about yourself

This may be a significant motivator in some households – it is an easy thing to be in control of, and it may also provide parents with an opportunity to teach their children about responsible behaviour patterns.

In the case of lighting in particular, and appliances to some extent, the behaviour is visible to visitors (and possibly also to neighbours and passers-by). This may contribute to the 'feel good' motive in relation to social norms, especially as awareness of climate change and energy wastage grows.

(i) Make my life easier

This behaviour does not itself make life easier but neither does it make life significantly more difficult once habits have been changed. However, it needs to be presented carefully because there is the potential that people will view switching off appliances as an inconvenience and waste of time.

Opportunity

The behaviour change is costless except for the possible small cost of purchasing new sockets or appliances to support the behaviour.

The most significant opportunity issue is likely to be time, in the sense of habit and the inconvenience of switching off. This means that changing habits and the technology to support the change should be the focus of action.

The cost being small, and the equipment generally portable, tenants should be prepared to invest and not rely upon landlords.

Energy-efficient lighting

Summary of change

Energy demand for lighting would be reduced if occupants installed low energy lighting, such as compact fluorescent lights (CFLs), with a power rating no higher than necessary, in all suitable light fittings. This includes outdoor lights, where additional gains can be achieved from solar power and automatic switching based on ambient light and/or motion around close to the light.

Potential CO₂ benefit

CFLs use about 20% of the energy used by standard tungsten filament (incandescent) light bulbs for the same light output, and last up to 15 times longer. Savings are increased by taking the opportunity to charge outdoor lights by solar power, and/or to limit their hours of use by automatic switching.

MMO Analysis

Means

The means would primarily be to fit low energy bulbs in all light fittings where incandescent bulbs would traditionally have been used. CFLs are the standard recommendation at present, although these are likely to be displaced by LED lamp technology over the next few years. Halogen bulbs offer some benefit but not as much as CFLs.

For outdoor use, lights are widely available that are charged during the day by solar power, then switch on automatically at night. These are typically low-power lights, for example to illuminate garden paths or for decorative effects.

Where powerful outdoor lights are needed (e.g. to illuminate driveways when coming and going from the house, or to support CCTV systems), solar power can still have a role but much energy can be saved by automatic switching. This is generally achieved by motion sensors and/or a photocell so they will turn on only when someone or something is moving nearby and/or at night.

Information should focus on:

- how CFLs differ from conventional light bulbs;
- the full range of benefits of changing from incandescent bulbs to CFLs;
- dispelling the myths associated with CFLs (i.e. the slow warm-up time, flicker, poorer light quality/tone, being bulky and unattractive, inability to be dimmed, and risk to health from mercury contained in them);
- remembering to switch lights off when a room is not in use (otherwise there is a temptation to

think that it is OK to leave them on because CFLs use less energy);

- the greater need to clean lamps periodically because their greater lifetime means they gather more dust;
- pointing out that solar powered lights do carry an energy penalty because of embodied energy, hence it is not 'green' to install them where there was previously no lighting at all.

The 'technology' or change being simple, there is high potential for messages to be passed on by friends, family and colleagues without expert intervention.

Some of the aesthetic concerns around low energy lighting may be at least partly counteracted by increasing householder awareness of the options around other, passive, factors such as the colour of the walls and the effects of uplighting and downlighting. There is a major role here for intermediaries such as electricians and decorators.

The only risk to be noted is the (very small) mercury content of CFLs, which can be mitigated by not breaking the lamps (in use or during disposal), not touching or inhaling dust from broken bulbs and disposing of all CFLs at approved facilities. Given that disposal is only infrequently needed, and breakage is very rare, this is not a major issue.

One barrier to change may be lack of availability of CFLs for all light fittings (e.g. those for 12 Volt tungsten-halogen bulbs or 'pygmy bulbs' as used in night lights). This applies particularly to tenants, as they may be unwilling to invest in changes to light fittings.

Motive

- (a) *Save the planet*
- (b) *Save the country*

Both motives apply and the fact that incandescent bulbs are being phased out will add to the credibility of the environmental message. Although the energy and carbon savings may be relatively small, the aggregated effect across all households can be significant.

- (c) *Save my household*

This motive is not likely to be strong – the impact on an individual household is minimal, as it will be the cumulative impact of all households making the change that will generate the desired effect.

(d) Save (or make) money

There has been significant publicity around CFLs, with much of the marketing identifying them specifically as “energy saving bulbs”, hence the potential to save energy and cut costs should be well known and generally accepted now. The capital investment is small (and getting smaller) and the payback period is short. The saving is small but easy to define because of regular purchases. Hence the financial incentive may be particularly strong.

(e) Avoid waste

Incorporating this measure in an overall message about not wasting energy might have more impact, particularly among higher income groups where money is less of a motivating factor.

(f) Wellbeing: be healthy, comfortable, safe and productive

This may act as a barrier for some people because of myths about CFLs, as noted above. However, some positive aspects which could be emphasised with householders are as follows.

- The relatively slow warm-up time (now seconds, not minutes as it once was) can actually be seen as an advantage, making it more comfortable to turn on a light when a person is adapted to the dark.
- There are prospects for CFLs with greater blue light content to correspond more closely to daylight, which may improve feelings of well-being.

CFLs can bring about a small reduction in personal risk because CFLs do not need to be changed as frequently as incandescent bulbs and do not become as hot in use, and generally have slightly stronger glass. Although small, this reduction in risk may be salient with some people, especially those with mobility impairment.

(g) Improve aesthetics

This may be a negative factor for some householders. Improving householder awareness of recent improvements in the technology will help combat these perceptions.

- Colour rendering (“tone”) is an issue because CFLs tend to have cool light quality which some people dislike or may alter the colour appearance of their decor. However, lighting manufacturers are developing CFLs with warmer tone and, in any case, the light quality can be modified by lampshades.

- CFLs are available in many sizes and shapes.
- Dimmable CFLs are also available, although in a limited range at present.

Fashion may also have a negative influence on this motivation – for example, the current fashion for spotlights in bathrooms and kitchens.

(h) Feel good about yourself

Lighting is, by its nature, a visible measure – especially if outdoors. Hence, some general points apply and, as CFLs become the norm, more people will use them for reasons of doing something for the wider good and promoting a positive self-image and/or avoiding negative reaction from the increasing number of friends and neighbours who understand why incandescent bulbs should not be used. There is also a potential role for lighting fashion stores.

There is likely to be less influence of:

- taking pride in the neighbourhood, city or country;
- developing a technical competence (except perhaps for being able to contradict myths);
- fulfilling a desire for self-sufficiency;
- association with role models.

(i) Make my life easier

CFLs sit comfortably in a ‘fit and forget’ culture as they rarely need to be changed – this may be a motivator for some people (though a weak one). However, this may be offset by confusion on how to dispose of them – which could in turn be offset by better information and education.

Installing outdoor lights with a photocell and/or motion sensor improves convenience by removing the responsibility of remembering to turn lights on and off.

Opportunity

Owing to the low cost, short payback time and small amount of time it takes to purchase and install CFLs, barriers to opportunity are relatively low. For outdoor lighting, costs may be higher (but still not prohibitive) if existing lights will be need to be completely replaced.

The cost being small, and the equipment portable, tenants should be prepared to invest and not rely upon landlords.

When householders are having major works done, they could be encouraged to change light fittings to those compatible with low energy bulbs.

Drying laundry

Summary of change

Energy demand would be reduced if laundry were dried naturally (outside or inside the home) instead of, for example, using a tumble dryer.

Potential CO₂ benefit

Replacing a tumble dryer with a ceiling airer to dry laundry could reduce annual CO₂ emissions by around 280 kg.⁶

MMO Analysis

Means

Laundry can be dried by various indoor and outdoor means; the approach taken will vary with the characteristics of the household, the home and the appliances within it, along with the seasons, weather and time of day. Hence, there is not a single means to reduce CO₂ emissions but rather a hierarchy with four main options.

- Option 1. Hang laundry outside.
- Option 2. Dry it inside the house (e.g. over a bath, on clothes airers or on radiators) or in a dedicated communal indoor space.
- Option 3. Use a tumble dryer.
- Option 4. Take wet items to a launderette (or someone else's home).

Option 1 is first choice, because it uses direct heat from the sun, but it is dependent on the weather and time of day when laundry can be dried. It also requires access to an outdoor area that is secure, free of dust, dirt and smoke, and ideally has direct sunlight for at least part of the day. While assessment on these criteria is, to some extent, subjective, some households will simply not have access to such an area. Conversely, the risks (or perceived risks) of this option are theft of items, soiling (e.g. from birds, nearby construction work or bonfires) and laundry not being dry when expected because of a change in the weather. A shelter over drying areas will extend the number of days when laundry can be dried outside.

Where Option 1 is not feasible, Option 2 is the first alternative but the energy demand will depend on circumstances. If the home is being kept warm by the sun, the energy demand is similar to drying outdoors. If the home is being heated, additional energy is used.⁷ The feasibility of Option 2 will

depend on space in the home and (in the heating season) the effectiveness of heating and ventilation, there being a risk of condensation if adequate ventilation is not maintained while keeping the home warm. It will also depend on personal preferences as discussed under Motive.

Preference between Options 3 and 4 is less clear; it depends on the energy to transport laundry to a launderette, whether it has to be taken there to be washed, and the efficiency of the dryers. Drying at home may sometimes be more energy-efficient if laundry would have to be driven somewhere just to be dried. If purchase of a tumble dryer is involved, the embodied energy also needs to be considered. Householders are unlikely to undertake this calculation but these are points they may consider.

If purchasing a tumble dryer, it is important to select an energy-efficient model, load it to the maximum recommended level and use it only when necessary.

For all options, a high speed spin at the end of the wash reduces the amount of water in the laundry, thus reducing the drying time (and condensation risk if laundry is dried indoors). Also, fabric can be ironed dry whilst slightly damp and so does not need to be completely dry (which allows further energy saving if use of a steam iron is avoided).

Information may need to be varied for different audiences, depending on the viability of the different options (e.g. in relation to drying space and family size). The selection of options is not fixed for a particular household – depending on the facilities available, a choice can be made each time laundry is to be dried.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All three apply to following the hierarchy in choosing a means to dry laundry; however, it is unlikely that most people will create a strong mental link between drying laundry naturally and saving the planet. Personal energy security will be enhanced a little by being able to dry laundry naturally, hence motive (c) is relevant.

- (d) *Save (or make) money*

This is likely to be significant, particularly for low income groups, because a reduction in tumble drying will save money. If purchase of a tumble

⁶www.mygreenerhome.co.uk/pages/clothes-airers-guide-pv-c0-23.html

⁷ If the home were a sealed unit, the energy would be recovered as the laundry and water vapour cooled and condensed indoors. In practice, some heat is lost. Conversely,

a benefit of having an energy-efficient well ventilated home is that it is more likely to be feasible to dry laundry indoors.

dryer is avoided, the saving is far greater. Where a tumble dryer is only occasionally needed, it can be more cost-effective to use a launderette (this could also reduce energy demand, as noted above). Care needs to be taken with financial aspects of Option 2 because it may appear to be free but could have some cost for heating and/or ventilation (and/or remediation of condensation damage).

(e) Avoid waste

Avoiding waste may be a strong motivator in terms of energy savings. Also, information regarding the life cycle costs of tumble dryers may discourage householders from making a purchase.

(f) Wellbeing: be healthy, comfortable, safe and productive

Tumble dryers can be noisy and add to overheating in summer, and there have been cases of fires initiated by lint on the heating elements. Drying laundry in the sun can be quicker and there is a small benefit of the combination of heat and ultra-violet light killing bacteria, mites and fungi. However, this motive also needs to be presented carefully in terms of Option 2 because there are several potential barriers:

- drying over radiators reduces their effectiveness in heating the home;
- sensitivity over visitors seeing washing around the house, particular underclothes;
- water dripping on the floor may cause staining or damage (especially if it is natural wood or carpeted);
- concerns about damp, mould and the associated health risks.

Some people prefer to use a tumble dryer because they like warm fluffy towels and warm socks. Another reason why people may choose to dry laundry indoors or in a tumble dryer is that they do not feel their laundry is secure outside. The incidence of theft from washing lines is probably low but official statistics are not available.⁸

(g) Improve aesthetics

The role of aesthetics would depend on whether laundry hanging round the house or washing lines are regarded as more unsightly.

(h) Feel good about yourself

Drying laundry outdoors is a visible activity, giving this motive the potential to influence behaviour, but it may play out in a number of different ways.

Laundry dried outside may give a sense of connection with nature, and also social benefits (e.g. it can provide an opportunity to chat to neighbours). Developing relationships with

neighbours is also likely to reduce concerns over security. Other people may choose to hang clothes outside as a means of displaying affluence (e.g. designer labels) but this should be handled with caution as some may consider the suggestion of this offensive.

Alternatively, hanging out the washing may carry a stigma of being old fashioned which could act as a barrier to some. Similarly, drying laundry inside may give a negative portrayal of social status, i.e. having no garden or tumble dryer. Therefore this motive needs to be applied in the context of the particular household, with a view to offering a positive perspective of drying laundry outdoors.

(i) Make my life easier

This motive may have negative or positive impact, depending on the choice being made. Using a tumble dryer may be seen as easiest (though not always – see notes below on time issues) but hanging laundry outside may be easier than hanging it indoors. Nevertheless, Options 1 and 2 may also be attractive to some people because of the possible disadvantages of tumble dryers:

- they can cause fabric to shrink, particularly as it is not obvious when laundry is already dry;
- they will require repair and/or replacement at some point.

Opportunity

Money is not likely to be significant matter of debate since the cost is either very low with a short payback time (e.g. a washing line and some pegs) or prohibitively high (e.g. buying a new house with a garden). Where the cost is small, and especially if the equipment is portable, tenants should be prepared to invest and not rely upon landlords.

Time may be a barrier to drying laundry naturally as there is an impression that it takes longer. However, tumble drying still requires laundry to be sorted and dried in batches.

Space is an issue for all options – outdoor space is likely to be the more significant issue (e.g. 70% of social housing is in flats, and the trend is to close in balconies to increase indoor floor space). In some homes, the issue may be space in the kitchen (for the dryer itself or to store/sort wet laundry whilst the dryer is full, especially if it is a small capacity washer-dryer) rather than space outdoors, in which case the opportunity is in favour of drying laundry naturally.

⁸ The British Crime Survey would report incidents in the same category as other loss of clothing through theft or burglary.

Adaptive use of clothing

Summary of change

Energy demand for space heating and cooling would be reduced if occupants made more use of variable clothing (and blankets and bedding) rather than instigating a change in temperature (e.g. by adjusting a thermostat or a heating or cooling appliance). This would apply to temperature variations over time (e.g. as the outdoor temperature varies) or in space (e.g. when moving between rooms). The change includes the possibility of greater flexibility in maintaining different rooms at different temperatures, depending on how (and how often) they are used.

Potential CO₂ benefit

The widening of acceptable temperature range can be estimated, from thermal comfort models, for the conditions in any particular building or space within a building. The potential would, of course, depend on the starting conditions of energy demand, temperature (air and radiant) and clothing, along with the other key variables of air velocity and turbulence, humidity and metabolic rate (i.e. level of physical activity and health).

Depending on the initial conditions, an expansion of $\pm 5^{\circ}\text{C}$ is feasible. This would equate nominally to about 50% of heating energy, based on a 10% saving per $^{\circ}\text{C}$ (or cooling energy if air conditioning is in use) but the absolute CO₂ saving depends on the rate of heat loss/gain through the building fabric and services, the efficiency of heating/cooling systems and the fuel supplying the energy. The benefit would be greatest for 'leaky' buildings with inefficient heating/cooling.

The benefit would be greater still if adaptation carried through into building design: buildings without air conditioning become more feasible if occupants will adapt to a wider range of temperature; furthermore, occupants become more adaptable if there is not air conditioning.

MMO analysis

Means

At first sight, the means is clear and simple: people would own and use clothing that suits the indoor environment. In most cases, this should not mean buying (and storing) extra clothing, but rather using existing clothing more adaptively. As an example, a light ensemble for women (T-shirt and thin skirt) replaced by layers of warmer clothing could achieve the same level of thermal comfort at a temperature about 5°C lower during the heating season. While seated for a period (e.g. when watching television), some people might prefer to

use blankets so that they can easily revert to what they see as "normal" clothing.

In cooled environments, reducing the equivalent of, for example, a 'standard business ensemble for men' (including long-sleeved shirt, jacket and tie) to a short-sleeved loose-fitting shirt and no tie, in hot weather would allow the upper bound of temperature to be increased by about 3°C . This is a minimum benefit – removing a tie, for example, increases local cooling by movement of air under the shirt, and also disproportionately improves local comfort around the neck.

The change would also be supported by easily operable precise room-by-room control of temperature (see "Heating controls" and "Space cooling"). Failing this, at least a whole-house thermostat would be beneficial. Even a thermometer (indoors and/or outdoors) would allow building users to obtain objective temperature readings and anticipate any need to change clothing.

The exact form of the means will depend on a range of factors such as age, wealth, season, climate and the range of environments experienced (e.g. whether the person is regularly moving between home, car and office, spending much time in well-tempered environments, or poor, elderly and concerned about energy costs).

There is also the potential to develop and/or market clothes that are either highly insulating but lightweight (for winter) or smart but cool (for summer). A number of fabrics already exist that perform this function, so engaging with the fashion industry to promote use of these fabrics, and 'cosier' styles for winter or cooler styles for summer, is a key enabler. This may be necessary in some cases, to overcome some motivational barriers, as noted below.

Information needs would focus on:

- the benefits from reasonable changes in dress, covering the key motive issues;
- some simple examples of changes in clothing ensembles, with energy cash values attached;
- a need to anticipate what an environment is going to be like in the course of a day.

The 'technology' being simple, there is high potential for messages to be passed on by friends, family and colleagues without expert intervention.

There is minimal and manageable risk of negative side effects (e.g. pollution or depletion of natural resources in the production of innovative fabrics).

Personal risks are also minimal but there may be a need to warn against excessive reductions in temperature (probably to below 16°C) because of:

- health risk from breathing cold air, especially if the occupants are very old, young, ill or otherwise vulnerable;
- risk to the building (e.g. from damp and mould if good ventilation is not maintained).

Motive

(a) *Save the planet*

(b) *Save the country*

(c) *Save my household*

(d) *Save (or make) money*

(e) *Avoid waste*

All five motives apply although, given the relatively mundane nature of the change, it may be more difficult for some people comfortably to create a mental link to (a), (b) and (c) – saving the planet by putting on a sweater seems a large jump in context. Saving money or avoiding waste are, therefore, likely to be the more direct motivations, especially for lower income groups.

(f) *Wellbeing: be healthy, comfortable, safe and productive*

This motive applies but needs to be presented carefully since people may see accepting higher or lower temperatures as a barrier, not a benefit. It is essential that the change is seen as a way of being comfortable at a more easily achievable temperature, rather than the environment making it more difficult to be comfortable. This will take a range of forms, depending on the exact circumstances, but could include:

- feeling allowed to dress as desired (e.g. to dress heavily in winter);
- avoiding the ‘thermal shock’ of coming into a building where the temperature is very different from outdoors (this factor may be linked to summer colds);
- maintaining adequate ventilation and/or being able to close windows to keep out noise without having to sacrifice thermal comfort.

Safety is probably not applicable except insofar as accident risk generally increases with heat stress.

(g) *Improve aesthetics*

This could be a positive motivational factor, especially if fashion trends encourage the ‘cosy’ image of blankets or warm clothing.

(h) *Feel good about yourself*

This motive has a mixed role – the means is visible but perceptions will vary. Some will adopt this behaviour for reasons of doing something for the wider good. There will be much less influence of

developing a technical competence or fulfilling a desire for self-sufficiency.

The remaining aspects of this motive may initially be seen as barriers but can become motives:

- promoting a positive image of the person, household or organisation occupying the building – a visible demonstration of action;
- gaining social acceptance or avoiding social rejection;
- association with role models;
- taking pride in the neighbourhood, city or country.

The difference lies in changing attitudes so that someone who wears extra layers in winter is seen as responsible and healthy rather than poor, mean, fanatic or ill. Similarly, acceptance of a more flexible ‘dress code’ in some households is critical to achieving change.

Role models (in ‘real life’ or in TV and film) may be particularly useful here, since they are less likely to be seen as making the change because they have to. For example, if the neck tie is to become history, the trend has to start in the workplace, preferably with the boss.⁹

The key is to show that different ensembles can be smart/fashionable/attractive and, perhaps, that it is more interesting to vary clothing through the year.

(i) *Make my life easier*

This is not likely to be a key factor this behaviour, except perhaps for not having to change dress substantially when going outdoors, especially for short trips (e.g. into the garden).

Opportunity

The change is a simple, cheap, quick, low-risk measure that people can easily understand. It is also likely to be of greatest benefit in buildings that are thermally least efficient. There are no specific barriers to tenants, as distinct from owner occupiers.

The main opportunity issues are likely to arise around lifestyle – taking time to think about the temperature in addition to image and ‘permission’ – moving the boundaries of what is considered normal or even positive.

⁹ “the retiring cabinet secretary, Sir Andrew Turnbull ... said as long as Whitehall staff still look authoritative and professional, there was no reason why a tieless civil servant should not turn up for meetings or deliver services to the public, particularly in hot weather.”

www.guardian.co.uk/politics/2005/jun/21/uk.Whitehall

Adaptive use of windows and ventilation: keeping cool

Summary of change

Energy demand for keeping homes cool would be reduced if occupants made better use of windows and other ventilation devices to provide 'free' cooling (in combination with other approaches – see "Adaptive use of clothing" and "Heating controls"). Engaging people in effective passive cooling strategies now may help to avoid uptake of air-conditioning as summers become warmer (see "Space cooling").

This behaviour generally means allowing the indoor temperature to follow the outdoor when that is the desired direction of change, but isolating the indoors from the outdoors when the desired indoor temperature is lower than the outdoor. Strategies also have to take into account thermal mass¹⁰ and the fact that ventilation also has to control indoor air pollutants.

Potential CO₂ benefit

The benefit arises from a combination of avoiding the need for air conditioning (a potential future step change in energy demand) and making less demand of installed cooling systems.

MMO Analysis

Means

People generally have some idea about using ventilation and shading to control the temperature in a building but it tends to be guided by a combination of intuition and behaviours learnt in an earlier generation of buildings with different options for control. Buildings vary widely in how leaky the fabric is, the ventilation and shading devices provided, and the thermal mass of the fabric. Hence, there would be some benefit in providing guidance on how to use particular combinations and whether it would be worthwhile for occupants to invest in additional facilities.

Information should focus on a simple decision process based on what ventilation and shading devices are available, how leaky the fabric of the building is and whether:

- the outdoor temperature is higher or lower than indoors;
- the sun is shining;
- it is windy or still.

The ventilation devices to be considered include large and small windows, trickle vents, passive

stack ventilation (with or without control, with or without heat recovery), open flues, mechanical extract ventilation and balanced mechanical ventilation systems with heat recovery (MVHR).

The permutations are too numerous to go into detail here but the following general points apply.

- Shade windows on the sunny side(s) of the property during the day (and anticipate the need for this, for example drawing the curtains before leaving for work so that the property remains cool and surfaces with high thermal mass are not heated by the sun). Interior curtains and blinds can be used but external shutters and blinds are more effective. Blinds set between the panes of double glazing are of intermediate effectiveness and have the advantage that they should not need cleaning.
- Trees that lose their leaves in winter will naturally provide shade in summer but let light through in winter – but don't plant them where roots may damage the building.
- If someone is at home during the day, open the windows when the temperature is higher indoors than outdoors. If the home is to be unoccupied until evening, and there is a secure option for ventilation (e.g. through small window openings) these openings should be left open when the home is unoccupied.
- Ventilate the home in the evening and at night, if possible by cross-ventilating (i.e. open windows on opposite sides of the building and/or upstairs and downstairs). This can both improve night-time comfort and cool the building fabric (thermal mass), which will keep the home cooler for longer the following day.
- Phase change materials absorb and release heat by changing between solid and liquid states – they can add to the cooling benefit of thermal mass. They are sometimes marketed as insulation products.
- The window design is relevant – side hung casements are less effective for ventilation than windows with top and bottom openings (including sash windows).
- Fans or open windows that create air movement (as distinct from ventilation) can also improve comfort, providing a cooling effect of about 2°C. The cooling benefit increases with air velocity and turbulence but so does the risk of uncomfortable draughts and skin/eye dryness.
- When replacing ventilation fans, install high-efficiency, low-noise models.
- Conservatories form a ventilation barrier (and a heating chamber). It is important that

¹⁰ The quality of materials such as brick, concrete, stone and tile to absorb heat when it is warm and release when it is cool.

householders understand this (preferably before adding a conservatory) and include the conservatory in their window-opening strategy.

- If it gets too warm in the winter, do not open a window – turn the heating down (or off) first.

Opening windows needs to take account of risks of intruders entering or occupants (especially young children) falling out. In both cases, well planned ventilation strategies with appropriate facilities (e.g. MVHR, trickle vents, small windows at high level) can reduce the risks.

Motive

(a) Save the planet

(b) Save the country

(c) Save my household

All apply but the link with saving the planet may not be salient to most users. The link may be stronger if something is purchased (e.g. shutters).

(d) Save (or make) money

Much can be done with whatever provisions exist, with no additional expenditure, hence changes should be financially attractive. Where investment is needed, it may be cost-effective, depending on the cooling need. Where householders understand that by employing a passive cooling strategy they are able to avoid the need for air conditioning, this may be a motivating factor.

The direct benefit on resale or rental value of the home is probably low except possibly for attractive features such as external shutters.

(e) Avoid waste

This may be a motivating factor for some households (avoiding waste of energy on air conditioning).

(f) Wellbeing: be healthy, comfortable, safe and productive

This is potentially a major motive because the behaviour is generally aimed directly at being more comfortable, and often driven instinctively by this need. There is also a strong health motive in terms of avoiding health complications (or even death) from overheating in very hot summers. This applies particularly to people who are elderly, very young or ill.

There may be perceived security/safety risks around leaving windows open but these risks can be managed, as noted under Means. External shutters and blinds can improve security.

External noise may discourage people from opening windows in some areas, especially at night, but external blinds can reduce noise if appropriately designed. Air conditioning systems

can be noisy, so avoiding the need for them brings an additional benefit.

(g) Improve aesthetics

This is not generally a significant factor but there are options for attractive curtains, shutters or blinds and overall the behaviour is a means of avoiding unsightly air-conditioning units.

(h) Feel good about yourself

This is not likely to be widely applicable, given the low visibility of most measures (external blinds excepted). Some may develop behavioural strategies for the reason of doing something for the wider good, being in control or developing (or passing on) a technical competence through the increased understanding of the use and benefits of appropriately used ventilation.

The motive of gaining social acceptance or avoiding social rejection may be a barrier within the home as a balance would need to be struck between occupants (e.g. how long the window is kept open) and comfort criteria are likely to vary from occupant to occupant.

(i) Make my life easier

This is not a motivating factor; given that some planning is needed for effective passive ventilation strategies, it may even be a negative motivation.

Opportunity

Time (to understand the building and develop a strategy) is likely to be a greater issue than cost unless behavioural options are significantly limited by the building and services (e.g. where the only means of ventilation available to occupants is large windows, this would limit the options). If the need for air conditioning can be avoided, there is a major saving of money.

A decision to change the windows or other ventilation provisions would also require time to work out what was worth doing, both economically and environmentally, and to manage the purchase and installation. However, such a decision is unlikely to be taken for reasons of ventilation alone and, therefore, other factors may help or hinder the change (see also "Multiple glazing").

In most cases, tenants would be able to develop strategies as effectively as owner occupiers.

Given the potential complexity of what might be seen as a simple change, it is essential to have clear and accessible guidance to make a convincing case for investment of time and money. This would include indicating where changes could be implemented when renovation works are planned, thus offering some saving in overall time and money.

Adaptive use of windows and ventilation: keeping warm

Summary of change

Energy demand for space heating would be reduced if occupants made better use of windows and other ventilation devices to provide 'free' heat and cooling (in combination with other approaches – see "Adaptive use of clothing" and "Heating controls").

This behaviour generally means allowing the indoor temperature to follow the outdoor when that is the desired direction of change, but isolating the indoors from the outdoors when the desired indoor temperature is higher than the outdoor. Strategies also have to take into account thermal mass¹¹ and the fact that ventilation also has to control indoor air pollutants.

Potential CO₂ benefit

The benefit arises from reduced demand on heating systems (saving perhaps 10-20% of related CO₂ emissions).

MMO Analysis

Means

People generally have some idea about using ventilation and shading to control the temperature in a building but it tends to be guided by a combination of intuition and behaviours learnt in an earlier generation of buildings with different options for control. Buildings vary widely in how leaky the fabric is, the ventilation and shading devices provided, and the thermal mass of the fabric. Hence, there would be some benefit in providing guidance on how to use particular combinations and whether it would be worthwhile for occupants to invest in additional facilities.

Information should focus on a simple decision process based on what ventilation and shading devices are available, how leaky the fabric of the building is and whether:

- the outdoor temperature is higher or lower than indoors;
- the sun is shining;
- it is windy or still.

The ventilation devices to be considered include large and small windows, trickle vents, passive stack ventilation (with or without control, with or without heat recovery), open flues, mechanical extract ventilation and balanced mechanical ventilation systems with heat recovery (MVHR).

The permutations are too numerous to go into detail here but the following general points apply.

- To keep the home warm at night, keep curtains or other window coverings closed.
- During the day, open window coverings to let the sun shine through windows into rooms, particularly on south- or west-facing facades. This benefit can be reduced if the windows are allowed to become very dirty or otherwise obscured.
- Exposed thermal mass will absorb heat during the day and release it at night – this is useful for keeping warm in winter. The benefit of thermal mass can be enhanced by allowing the sun to shine onto indoor surfaces such as brick, concrete, stone and tile.
- There are products called "phase change materials" that can be used to absorb and release heat by changing between solid and liquid states. These are sometimes marketed as insulation products.
- Open windows when the outdoor temperature is comfortable and higher than indoors.
- Close windows when heating the home. If it gets too warm in the winter, do not open a window – turn the heating down (or off) first.
- Before increasing ventilation to remove water vapour, odours or other indoor air pollutants, think about a hierarchy of approaches: can the source of pollution be eliminated, reduced or isolated? If not, is local ventilation available (e.g. a cooker extract hood)? If more ventilation is needed, turn it off again as soon as possible.
- Unoccupied rooms generally need less ventilation, unless there is some other source of moisture or air pollutants in the room.
- MVHR can save energy in a building with a low air leakage rate. But use windows and other passive devices when the temperature is similar indoors and outdoors. The more airtight the building fabric, the more need there is for windows and mechanical systems to provide adequate ventilation, but it is more energy-efficient to have planned and controlled ventilation than uncontrolled air leakage. With sufficiently high levels of insulation, MVHR can eliminate the need for a heating system proper.
- Conservatories form a heating chamber – this is beneficial for 'free heating' but the conservatory itself should not be heated.

The risks are related mainly to maintaining sufficient ventilation to deal with condensation, odours and other indoor air pollutants, without excessive energy use. This applies particularly where there are combustion appliances with an

¹¹ The quality of materials such as brick, concrete, stone and tile to absorb heat when it is warm and release when it is cool.

open flue (e.g. an open fire or some older boilers) or no flue (e.g. heaters using bottled gas).

Opening windows also needs to take account of risks of intruders entering or occupants (especially young children) falling out. In both cases, well planned ventilation strategies with appropriate facilities (e.g. MVHR, trickle vents, small windows at high level) can reduce the risks.

Motive

(a) Save the planet

(b) Save the country

(c) Save my household

All three apply but the link between simple behavioural strategies and saving the planet may not be salient to most users. Where new equipment is purchased (e.g. MVHR), the link may be stronger.

(d) Save (or make) money

Much can be done with whatever provisions exist, with no additional expenditure, hence changes should be financially attractive. Where investment is needed, it is likely to be cost-effective.

The direct benefit on resale or rental value of the home is probably low but the behavioural strategy should reduce fuel bills and may therefore have a small positive effect on the resale or rental value of the home. The value would be greater where significant physical measures are introduced (e.g. external blinds or MVHR).

(e) Avoid waste

This may be a motivating factor for some households.

(f) Wellbeing: be healthy, comfortable, safe and productive

This is potentially a major motive because the behaviour is generally aimed directly at being more comfortable, and often driven instinctively by this need. There is also a strong health motive in terms of avoiding health complications (or even death) from cold in winter. This applies particularly to people who are elderly, very young or ill.

Perceived security/safety risks and/or external noise may encourage people to keep windows closed. External shutters and blinds can also reduce noise and improve security.

(g) Improve aesthetics

This is not generally a significant factor but there are options for attractive curtains or blinds.

(h) Feel good about yourself

This is not likely to be widely applicable, given the low visibility of most measures (external blind excepted). Some may develop behavioural strategies for the reason of doing something for the wider good, being in control or developing (or passing on) a technical competence through the increased understanding of the use and benefits of appropriately used ventilation.

The motive of gaining social acceptance or avoiding social rejection may be a barrier within the home as a balance would need to be struck between occupants (e.g. how long the window is kept open) and comfort criteria are likely to vary from occupant to occupant.

(i) Make my life easier

This is not a motivating factor. Indeed, given that some planning is needed for effective strategies, it may even be a negative motivation.

Opportunity

Time (to understand the building and develop a strategy) is likely to be a greater issue than cost unless behavioural options are significantly limited by the building and services (e.g. where the only means of ventilation available to occupants is large windows, this would limit the options).

A decision to make a change to the windows or other ventilation provisions would also require time to work out what was worth doing, both economically and environmentally, and time to manage the purchase and installation. However, such a decision is unlikely to be taken for reasons of ventilation alone and, therefore, other factors may help or hinder the change (see also "Multiple glazing").

In most cases, tenants would be able to develop strategies as effectively as owner occupiers.

Given the potential complexity of what might be seen as a simple change, it is essential to have clear and accessible guidance to make a convincing case for investment of time and money. This would include indicating where changes could be implemented when renovation works are planned, thus offering some saving in overall time and money.

Heating controls: installation and use

Summary of change

Buildings would be more energy-efficient if the occupants had, and made adaptive use of, heating controls such as thermostats and timers to supply heat only where and when it is needed.

Potential CO₂ benefit

The benefit is literally for energy efficiency, not necessarily energy savings: delivering heat where and when it is needed could increase energy use but use that energy efficiently (in the sense of achieving a goal with minimum input) – e.g. heating might be kept on longer where controls facilitate this. However, it is estimated that good controls can save about 17% of heating energy.

MMO Analysis

Means

Heating controls should allow occupants to achieve reasonable desired temperatures in each room at their chosen times. This means use of thermostats to control both (a) the temperature of the air or water delivered by the heat source and (b) the room temperatures at which heat supply and/or delivery ceases. It also means using timers to control when heat is delivered in each room or zone, or at all. Where the temperature set point varies between rooms, keeping room doors closed is a key part of the strategy.

In the common situation of heating based on a gas-fired boiler and hot water delivered to radiators, for example, the controls could be a room thermostat, a thermostat on each radiator and the boiler itself, and a seven-day timer to provide independent regulation of space heating and hot water. Condensing boilers are generally more efficient at the lower water temperature settings, so higher settings should be used only when the outdoor temperature demands it.¹²

The means can be relatively simple or more complicated, depending on the exact controls provided, the number of rooms and the spatial and temporal pattern of occupancy. More complicated controls can deliver greater savings but only if the instructions are clear and occupants have the understanding and time to make best use of them. Variability in controls can also be a barrier to some householders installing new equipment, because of the need to learn how to use a new system (which may not be intuitive).

There is research evidence¹³ that homes with heating timers have the heating on for more of the time. Hence it is crucial that controls allow occupants to easily achieve an optimal heating pattern and that all heating controls are accompanied by guidance on how to make best use of them, not just how to operate them. Targeted building-specific personal help may be required in setting up and operating any new control system. Guidance should focus on the following.

- What heating controls are present and what improvements could be made, taking into account both the technology and the potential for its efficient use by the current occupants.
- How to source and install additional controls, and any available financial support.
- For the controls actually fitted (or to be fitted), advice how to use those controls – e.g. giving an understanding that heating should come on a short while before a space is due to be occupied, but can turn off before it is vacated.
- The personal and environmental benefits.

Showing a narrower range of temperatures on thermostats, and lower set points in product literature, may help encourage householders to use lower set points.

Insulating radiators (by putting decorative covers over them) reduces heat input to the space and makes control by thermostatic radiator valves (TRVs) less effective because the temperature inside the cover will be higher than in the room.

For households where an open fire is in use, some additional issues of control apply and the following advice may be useful.

- The fireplace damper should be closed unless a fire is lit; keeping the damper open allows warm air to escape up the chimney.
- When a fire is lit, heat loss is reduced by opening dampers in the bottom of the firebox (if provided) or by opening the nearest window slightly and closing doors to the room.
- If a room with an open fire also has central heating, reduce the thermostat setting in the room to 10-13°C.

¹² This does not apply to conventional boilers, which can have corrosion problems operating on lower water temperatures.

¹³ Shipworth D (2009). Paper on CaRB findings, presented to ESRC seminar "How people use and misuse buildings", January 2009.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save me*

All apply but, given the relatively simple nature of the change, for some people it may be difficult to make a connection with these motives.

- (d) *Save (or make) money*
- (e) *Avoid waste*

These motives are likely to have a greater influence, particularly where the necessary controls are already present. The direct benefit on resale or rental value of the home is probably low but, with the increasing influence of Energy Performance Certificates, the contribution to overall energy efficiency will have some benefit at the point of sale or rental.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

This is likely to be a key motive, in terms of providing a preferred temperature, where and when it is needed: avoiding both under- and over-heating. While comfort may be the main consideration, mitigating health risks will be important to some. The very young and the elderly are more vulnerable to the consequences of both low and high temperatures.

The strength of the motive, and the detail of the way it operates, will depend importantly on 'lifestyle' factors such as pattern and predictability of occupancy, and how important it is to have the home at a particular temperature under given circumstances. For example, controls can be used to ensure the home is at a desired temperature on getting up in the morning (but not earlier), when going to bed at night, or when arriving home (e.g. from work or from several days away from home).

By controlling the temperature room by room it is also possible to reduce the risk of condensation. If some rooms are unheated, warm moist air can flow from heated into unheated rooms, causing damp and mould. Temperature control in each room means that each room can be kept at a minimum temperature to avoid this problem. In some cases, this will use more energy but this could be offset by the long-term benefits (including CO₂ savings) of protecting both the health of the occupants and the fabric of the building and furnishings.

Limiting the temperature of radiators can reduce the risk of minor burns, especially to young children and people who are physically not able to react quickly if they touch a hot surface.

- (g) *Improve aesthetics*

This is unlikely to be a motivating factor, unless as a side-effect of replacing dated equipment.

- (h) *Feel good about yourself*

Some may improve their control over heating to develop a technical competence because it provides ongoing interaction with the system to get optimal performance, and a sense of control. There may also be elements of passing on knowledge to the children, gaining social acceptance and promoting a positive image through not overheating, and of doing something for the wider good by reducing energy demand.

The controls themselves have little visibility so the potential will depend on the visibility of their impact (or lack of it) and the social context. The remaining motives under this heading are unlikely to be significant, i.e. fulfilling a desire for self-sufficiency; association with role models; and taking pride in the neighbourhood, city or country.

- (i) *Make my life easier*

This may be a negative factor, as the initial need to learn how to use a new set of heating controls may be daunting or aggravating. However, this can be set against the fact that modern controls are often more flexible, and when combined with TRVs, can reduce the need for constant adjustment or switching of heating systems (e.g. to maintain different temperatures in different rooms).

Opportunity

Where sufficient heating controls are already in place, the change is simple and carries no significant cost. It is therefore open to both tenants and owner occupiers. The cost can be spread by adding controls incrementally but the total labour cost should be less if all the work is done in one visit (and cheaper still if done when other work is done by the same professional, e.g. when a boiler is serviced). TRVs, in particular, can be installed at reduced labour costs when the heating system is drained down (e.g. if a new boiler is installed).

There may also need to be some investment of time to learn and implement a strategy, perhaps including a period when the occupants experiment to get the most efficient results for their lifestyle/home. Therefore, the advice element that must accompany this change is crucial.

Where controls are absent or inadequate, some money will need to be spent but the means are relatively inexpensive and the payback period can be short (especially if controls are simply being upgraded with new devices in the same locations). Even tenants may see some benefit and could, if they wished, take some devices with them (putting back the old devices) or sell them on to the landlord or new tenants when they move on.

Space cooling

Summary of change

The first step in reducing energy demand for space cooling is to avoid the need for mechanical cooling (air-conditioning), by some combination of building design for passive cooling, occupant behaviour and accepting temperatures that are – while not optimal – not harmful. This is covered under “Adaptive use of windows and ventilation” and “Adaptive use of clothing”. This information sheet deals with the very limited situations where this is genuinely not possible, in which case any mechanical cooling system should be energy-efficient, used minimally and controlled efficiently.

Potential CO₂ benefit

The efficiency and effectiveness of domestic air-conditioning units varies widely, depending on the system, the temperature and humidity of the environment and the temperature set point - measured coefficients of performance range from less than 1.0 (for some portable units) to about 3.0 for single split units cooling the air from 30 to 25°C.¹⁴ Further large gains can be made in controlling the system such that, where air conditioning is deemed necessary at all, rooms are not cooled more than required.

MMO Analysis

Means

The means comes in two parts. First, if air conditioning is required, install an efficient system. For an individual dwelling, as distinct from a communal system, this may mean a greater capital cost. Where a portable system is the only viable option, ensure that heat is discharged outdoors, through an opening that is as well sealed as possible to avoid warmer outdoor air entering the building. Larger, centrally managed systems can be more efficient but need to be controllable at the level of the individual dwelling, and billed to each household according to use, so that energy is not wasted.

Second, fit and use controls to avoid wasting energy; this could include some or all of the following measures.

- Avoid over-complicated controls that deter users.
- Use timing controls to provide cooling only when it is needed, preferable by room or zone, and not in conservatories.

- Use thermostatic controls for the cooling device and each room or zone of the home, so that already cool rooms are not unnecessarily continuously cooled.
- Set maximum temperatures by room, day and time of day to reduce energy use. One study found that daytime temperatures tend to be set at a reasonable level (about 25°C) but bedroom temperatures are set lower – sometimes lower than the temperature to which they are heated in winter.¹ CIBSE¹⁵ guidance gives comfort thresholds of 25°C for living areas and 23°C for bedrooms, with overheating thresholds of 28°C and 26°C respectively.
- Experiment by turning up thermostats until it is comfortably warm.
- Do not open windows when the system is running if it is warmer outdoors than indoors.
- Do not place heat sources near air-conditioning thermostats: they can cause the chiller to run longer than necessary.
- Maintain systems in good order (see “Maintenance of heating, cooling and ventilation systems”).

The means would need to be accompanied by explanation of what it would involve, i.e. information on how to make best use of passive cooling to eliminate the need for mechanical cooling and – where cooling units are required – information on where to purchase systems and controls, how to get them installed and their most efficient use. As far as possible, any literature produced by intermediaries for householders should show higher set-points (e.g. 25°C).

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*
- (d) *Save (or make) money*
- (e) *Avoid waste*

All five general motives apply to efficient use of air conditioning (and to the avoidance of air conditioning), and may be fairly significant because the need for air-conditioning in the UK is limited and therefore an active move away from mechanical cooling to passive cooling may give users a sense of taking a logical cost-saving approach to saving the planet and reducing dependency on energy supplies. Installing air conditioning (or buying/renting a home that has it), and maintaining and running the system, is

¹⁴ Young A N, Pathan A and Orescyn T (2007) Domestic air conditioning – occupant use and operational efficiency. Final report from University College, London, to EPSRC.

¹⁵ Chartered Institution of Building Services Engineers.

expensive so the financial incentive should be of particular significance.

(f) Wellbeing: be healthy, comfortable, safe and productive

The prime reason for using air conditioning is comfort but most people do not have air conditioning at home so there is an opportunity now to avoid getting into a situation where they have it and therefore expect to continue to have it. In the absence of air conditioning, people are generally much better at adapting to a range of temperatures.

There are also negative aspects to be considered in respect of this motive. Air conditioning systems have been associated with a range of health effects, from sick building syndrome to Legionnaires' Disease but this is primarily in the workplace and large leisure facilities, where the air-conditioning system can be complex, poorly maintained and operated, and carry risks from wet cooling towers and long, inaccessible ducts.

Domestic systems tend to be simpler and use dry cooling components but there are still risks if they are faulty or unhygienic (see "Maintenance of heating, cooling and ventilation systems"). Generally, the health and comfort motives for not using domestic air conditioning are likely to be a series of lesser issues:

- cold draughts;
- discomfort or the inconvenience of having to change clothing because of the difference between outdoor and indoor temperature;
- visitors not being dressed for the low temperature;
- poor ventilation – either deliberately to reduce energy demand or because a cool room gives a false impression of being well ventilated;
- odour from ducts and filters;
- noise (indoors or outdoors) from chillers and fans.

(g) Improve aesthetics

Air-conditioning units are not generally considered to be attractive to look at.

(h) Feel good about yourself

For some users, using passive cooling or actively taking greater control over the use of an air-conditioning system may generate a sense of developing a technical competence.

Image issues are more complex – the presence of air conditioning (or its effects) is generally visible, sometimes from outside the home, but the perception depends on the social context. For some, having a home that is slightly too warm may be associated with a negative image – role models

probably do not help in this respect. For others, using energy for air conditioning would be the greater cause of embarrassment, especially if the home is cooled more than it needs to be and visitors feel uncomfortable.

With increasing awareness of climate change, the message "cool is not cool" may come to dominate but there are still barriers to overcome. In particular, the increasing use of air conditioning in workplaces, trains, coaches and particularly in cars may create an expectation of air conditioning in the home. Three important differences between homes and cars are that, in cars:

- overheating is a safety issue as it can make the driver less alert;
- increasing thermal mass is not a serious option because it generally increases vehicle weight more than air conditioning does, and thus increases fuel consumption and/or reduces vehicle performance;
- the alternative of opening windows also wastes fuel (because of increased drag), especially at higher speed.

(i) Make my life easier

This is not likely to be a significant positive motive and may be seen as negative.

Opportunity

There is a significant cost saving in not having air conditioning or limiting its use. Some investment may be needed to make passive cooling effective (e.g. installing external blinds) but the capital cost should be lower and the operating cost minimal.

Specific issues for tenants are therefore minimal: they are generally not in the position of asking landlords to install something. In the unusual case of air conditioning already being installed, tenants do not have to use it, and can thus save money. The more difficult position would be if the building was not designed to be able to keep comfortable without using the air conditioning; this is likely to apply to a few cases, mainly at the high end of the rental market, where tenants generally have a choice of alternative accommodation.

The greater opportunity barrier is likely to be time; good generic advice, and advice tailored to particular households, is therefore critical: strategies for passive cooling or sensible use of mechanical systems can take time to work out and execute; flicking a switch on the air conditioning is easier.

Where air conditioning is already installed, the main issues are likely to arise around habit, i.e. if someone is used to switching on an air-conditioning unit when it is hot and not opening a window or drawing blinds, changing habits could be difficult.

Control and use of domestic hot water

Summary of change

Energy demand for hot water would be reduced if a three-part strategy were followed:

- fit controls to avoid overheating the water;
- fit controls for the timing of domestic hot water (DHW) supply so that it is available only when needed and in the volume needed;
- do not waste hot water.

Potential CO₂ benefit

Constant replacement of hot water at 60°C in a poorly insulated vessel can waste more than half the energy used. This is an extreme but good insulation can save around 190 kg of CO₂ per year and insulating hot water pipes can save around 60 kg. Overall, it is not unreasonable to target 10% savings from improved control.

MMO Analysis

Means

The means is a combination of how much water is heated, to what temperature, when, how much is stored, the heat loss during storage and how much hot water is needed at various times of the day and week (see also "Heating controls"). So users need to think about when they will need hot water, to ensure it is heated only once before use, not two or three times. In the interests of simplicity, the strategy can be reduced to four main elements.

1. DHW temperature is controlled by a settings on the boiler and (if present) the hot water storage vessel ('hot tank'). If the boiler provides both heating and DHW, and heating dictates the higher temperature, the DHW temperature can be limited by controlling the temperature of stored water and/or using thermostatic mixer valves to add cold water before delivery at outlets (taps, showers, etc.).
2. Timing devices should allow independent control of hot water and heating. Each household will have different demands for DHW (when it is needed and how much) so flexibility of control is essential. This is particularly so if there is any supplementary water heating (see also "Solar thermal water heating").
3. Hot water should be used only as needed (examples as follows).
 - Fit an energy-efficient shower as an alternative to a bath.
 - Take showers instead of baths (but note that this common advice applies if the shower is short and the water flow rate is no higher

than necessary). The volume of water used in showers can be monitored using inexpensive flow/timing devices. Users also need to know that heating water by main electricity produces more CO₂ than heating it by gas.

- Run only as much bath water as is needed for washing.
 - Use low-flow outlets such as spray taps and low-flow shower heads, unless the flow is so low that it is more than compensated by running water for longer.
 - Turn outlets off when they are not in use (e.g. while brushing teeth or between rinses when washing hair). This is facilitated by having outlets with ceramic washers and lever controls so that turning on or off is a quick single action.
 - Fix dripping outlets.
 - Avoid heating a full tank of water when less is needed (e.g. a shower may need only half a tank). For small volumes (e.g. washing up by hand) a kettle or instantaneous electric hot water heater may be more efficient.
4. Reduce heat loss: ensure that hot water tanks and pipes (especially any that run through an unheated space) are well insulated. Insulation on hot water tanks should ideally be 75 mm thick where space allows. Also avoid 'dead-legs' and long pipe runs to outlets.

The means is complicated further by consideration of risks: there is a balance between setting a low temperature to reduce the risk of scalding (and possibly save energy) and a high temperature to avoid colonisation of hot water storage vessels and pipes by bacteria (including *Legionella*). A setting of 55°C is probably optimal but this will depend on the actual *Legionella* risk (which is low if cold water storage is maintained in a hygienic condition) and the vulnerability of the household to scalding (e.g. whether there are young children or frail elderly people). Water can be stored safely at higher temperatures if there are thermostatic mixing valves on all outlets. Mixer taps at the outlets can also be used, and are cheaper, but are dependent on being used safely.

In addition to the controls themselves, information should be provided on their energy and non-energy benefits and specific guidance on how to (a) adjust the controls and (b) decide on settings. It may be useful to be able to provide generic advice based on certain home situations (e.g. for an elderly couple, a young single person or a family with infant or teenage children).

Some other approaches to saving energy for hot water are out of scope because they are not related to the building or its fixed services (e.g. hot water in kettles/saucepans, washing machines and dishwashers). Also, with dishwashers and washing machines becoming more water-efficient (and often cold-filled) the main use of hot water in the home is now for bathing.

Reducing cold water usage also has an energy benefit, because energy is used, for example, to pump and purify water. This is not specifically covered here but is worth noting in cases where householders may assume that water heated using renewable energy sources carries no CO₂ penalty.

Motive

(a) Save the planet

(b) Save the country

(c) Save me

All three apply but temperature and timing controls are a relatively common and indistinctive feature and some users may find it difficult to create a mental link between fitting controls and saving the planet. Saving water may, however, be a specific motive for some people, more than saving energy – especially in times of water shortage or if they have concerns about flooding land for reservoirs.

(d) Save (or make) money

(e) Avoid waste

Saving money will probably be the biggest consideration for those people making the change for non-energy reasons, especially for those who have a good understanding of the benefits of controls and how to use them.

The direct benefit on resale or rental value of the home is probably low but, with the increasing influence of Energy Performance Certificates, the contribution to overall energy efficiency should have some benefit at the point of sale or rental.

Avoiding waste may also be a motivation, even for those who are affluent enough not to be concerned about money. Monitoring hot water use may help to engage this motive.

(f) Wellbeing: be healthy, comfortable, safe and productive

While reducing the risk of scalding and Legionnaire's Disease adds complication to the control process, it is also a benefit of good controls, especially where there is vulnerability to scalding (as noted above) or to pneumonia illnesses (e.g. being more than 50 years old or having a compromised immune system).

For some people, the issue may be having enough hot water to keep clean and healthy. Having good

controls can help to ensure that hot water is available when needed and this may motivate people to fit controls and/or avoid wasting large amounts of hot water.

When encouraging householders to limit their hot water use, be aware of the 'comfort' motivation of taking a bath or long shower, which may be an important relaxation opportunity, outweighing the energy or water efficiency argument.

(g) Improve aesthetics

This is unlikely to be a key motive, as the focus is on an activity rather than on investing in an item that may have aesthetic benefit.

(h) Feel good about yourself

System controls are not a highly visible or engaging technology, and most use of hot water goes unobserved, so this motive is unlikely to be a major factor except for some individuals who enjoy planning and implementing a control strategy.

However, social norms may become a strong motivator, if wasting energy or water is seen as unacceptable.

(i) Make my life easier

This may be a motivating factor, as a well controlled hot water system that provides hot water when needed will potentially make the householder's life easier.

Opportunity

Controls and efficient water outlets are mostly not excessively expensive. The cost can be spread by adding controls incrementally but the total labour cost (plumber and/or electrician) should be less if all the work is done in one visit (and cheaper still if done when other work is done by the same professional, e.g. when a boiler is serviced). Each system needs to be assessed, however, because the cost of providing a complete set of controls will be higher if certain basics (e.g. a thermostat on the hot water vessel) are missing.

Tenants may see some benefit, in amenity if not in energy savings, and some devices will be removable when the tenants move house.

The main barrier is likely to be simply a lack of time to gain an understanding of the means or to reconsider lifestyle or change habits of use. Strategies to reduce hot water use need to be simple and easy to remember so that they become second nature. In a majority of energy saving campaigns there tends to be a focus on reducing the room temperature rather than controlling the temperature of hot water, so promotion of the benefits may be enough to overcome this barrier. Intermediaries such as water companies and plumbers may be helpful in this area.

Maintenance of heating, cooling and ventilation systems

Summary of change

Energy demand would be reduced if heating, cooling and ventilation systems were well maintained to keep them running efficiently and for longer.

Potential CO₂ benefit

The benefit would vary widely, depending on the systems installed, but would arise from a combination of reduced energy wastage in use (e.g. clean air filters present less resistance to air flow), fewer breakdowns (entailing travel for repairs and, often, use of less efficient portable heaters for a period) and less frequent replacement (i.e. embodied energy).

MMO Analysis

Means

The means would be to maintain heating, cooling and ventilation systems to ensure they are running efficiently. This would include, for example, the maintenance of boilers, flues, heat pumps, cooling units, fans, filters and water pumps.

Establishing the means will also entail publicising a clear explanation of how frequently service work should be carried out, where to go to get the system serviced and why systems should be maintained.

Maintenance contracts and insurance policies also have a role to play in ensuring maintenance is carried out while controlling the cost of the maintenance.

Whilst a plumber or heating engineer is in the home, there is an opportunity to act as an intermediary to inform the householder about other desirable behaviours related to heating, cooling and ventilation. For example, s/he can check that the heating controls are understood, and are appropriately set, and can discuss ways the householder can save energy (and money) by altering heating settings, draughtproofing, etc. In order for the plumber not to seem like a 'rogue trader', it is important that such activity is either clearly to the householder's benefit, or is backed up by other information from an independent 'trusted source'.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All apply because well maintained systems use less energy. However, the link between a well maintained boiler and motives (a) to (c) may be difficult for some users to grasp. Hence, other motives may be more important than these three.

- (d) *Save (or make) money*
- (e) *Avoid waste*

These motives may be of greater significance but more quantitative evidence may be needed in order to make a strong financial case to householders for an investment in regular maintenance – covering reduced energy wastage in use, fewer breakdowns and less frequent replacement. One key element is that the warranty on a new boiler is likely to be invalidated if it is not serviced as specified, leading to a risk of expensive repair bills.

Good maintenance and a 'service history' may also have a small positive effect on the resale or rental value of the home.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

Health and safety are likely to be of some significance. Apart from a general appreciation that cleanliness is associated with healthiness, there are specific issues with failure to maintain systems.

- Poorly maintained boilers, or those with blocked or leaking flues, can lead to carbon monoxide poisoning.
- Ducts and filters need to be kept clean to avoid odours and potentially harmful microbial growth, especially where there is high humidity in the ducts.
- Wet cooling systems are generally not used in UK homes but, if ill-maintained, are particularly prone to colonisation by bacteria (including *Legionella*) and fungi.
- A well maintained system tends to run quieter, which may be of particular significance in smaller dwellings and/or where noise is produced close to the living space.
- System breakdowns are inconvenient and often happen in winter when heating systems are under greatest load.

- More generally, having the knowledge that the system is well maintained and therefore reliable reduces any unnecessary stress and worry.

Whilst motive (f) is likely to be significant, some householders may think that, if the system has not broken down, it is in good order. This misconception needs to be countered in advice given to householders.

(g) Improve aesthetics

This is unlikely to be a relevant motive.

(h) Feel good about yourself

System maintenance is not a very visible or socially relevant activity, hence this motive is not likely to be significant for most households.

(i) Make my life easier

This may be a relevant motive, in that preventative maintenance will reduce the likelihood of breakdowns leaving the householder without heating or hot water (and possibly having to take time off work to organise repairs).

Opportunity

The cost is generally low although, as noted above, the financial payback period can be difficult

to state in a convincing way – partly because benefits are distributed over time unevenly and probabilistically (i.e. it is uncertain when performance will deteriorate or when repair or replacement will be necessary).

Time may, in practice, be a more significant barrier – the time required to find a supplier, organise the service and to stay at home for it to be carried out. By encouraging home owners to sign up to a maintenance contract, this barrier could be reduced.

Some warranties and system insurance policies require a regular service to be carried out (or include a service in the price); in such cases, the actual or perceived cost of ensuring that maintenance is carried out may be reduced.

In the rental sector, there is a reversal of the well known impasse that landlords would have to pay for energy efficiency measures but tenants would benefit, therefore nobody pays. Where a landlord is responsible for maintenance, tenants are in a strong position to demand the landlord commission routine maintenance of heating, cooling and ventilation systems under the tenancy agreement.

Draughtproofing

Summary of change

Energy demand for space heating would be reduced by draughtproofing homes, while ensuring the ventilation remains adequate to protect both the occupants and the building itself.

Draughtproofing reduces air leakage through the building envelope (walls, floor, roof, windows and doors) to reduce heat loss.

Potential CO₂ benefit

Draughtproofing can reduce CO₂ emissions by around 150 kg per year.

MMO Analysis

Means

The means would be to install draughtproofing measures to reduce heat loss through the envelope of a home (or heat gains, if the home is air-conditioned in summer) and cold draughts. Methods include the following.

- Caulk and weather-strip doors (including letterboxes) and windows.
- Add caulking around skirting boards and seal gaps in floorboards.
- Add caulking around the loft hatch.
- Caulk and seal air leaks where plumbing, ducting or electrical wiring penetrates through exterior walls, floors and ceilings.
- Install gaskets behind outlet and switch plates on exterior walls.
- Plug and seal the chimney flue of fireplaces that are not used, leaving a small opening to ventilate the flue itself.
- Add caulking around unused fireplace hearths.
- Adding a vestibule or porch to entrance doors will also help reduce draughts through the doors, and provide an air-lock to limit heat loss when the door is opened.
- Fitting substantial shutters will also help, and may be particularly appealing to tenants. Curtains will not affect air leakage but can reduce the draughts that arise indoors because of cold window surfaces.

There are various means that can be used to identify significant gaps in the envelope, from professional pressure testing to observing draughts when the wind blows (by feeling the draught or by visualising with fine powder or smoke from a candle). Alternatively, a whole building can be made more airtight using external wall insulation – this will save much more energy

but is an expensive professional job (see “Solid wall insulation”).

Establishing the means will also entail publicising a clear explanation to potential users of the various methods that can be used to draughtproof a home. It may also be necessary to comment on some older draughtproofing measures that were problematic and put people off attempting it again. For example, some sealing materials broke up quickly, were aesthetically unappealing and, if installed incorrectly, stopped doors closing. To overcome such a barrier there should be emphasis on good materials (conforming to standard BS 7386) and clear guidance on installation.¹⁶

As part of the explanation to encourage users, the option of doing it piecemeal (e.g. one room at a time or one type of work at a time) should be pointed out. This will make it a less daunting task for someone who is concerned about cost and time.

There are risks involved which would also need to be highlighted.

- Adequate ventilation is still necessary for health and comfort, particularly in homes that have open flues (e.g. for solid fuel fires, gas fires or some older boilers).
- A high level of draughtproofing, without planned and controlled ventilation, can lead to damp and condensation, particularly in kitchens and bathrooms.

In practice, it is difficult for an amateur to make a home so airtight that this is a problem but care needs to be taken not to block airbricks or other openings that have been put in place for a purpose. Older properties in particular may require professional input to deliver adequate draughtproofing.

When a home is made very airtight, it is increasingly common to install mechanical ventilation with heat recovery to ensure adequate ventilation without wasting energy (see “Adaptive use of windows and ventilation”).

¹⁶ The Draught Proofing Advisory Association (www.dpaa-association.org.uk/) can advise.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

These are all likely to apply but the link between sealing windows and doors and saving the planet is likely to be weak for many householders.

- (d) *Save (or make) money*
- (e) *Avoid waste*

These motives are likely to be significant because it is possible to save energy (and thus money) quickly with relatively cheap measures and low installation fees or DIY installation.

There may also be some benefit on resale or rental value of the home if it would otherwise clearly feel draughty during viewings.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

Comfort will more than likely be the most important motive for draughtproofing. It provides an immediate answer to cold draughts.

Comfort, for some people, may also derive from a reduction in noise caused by a leaky building envelope (noise from outside and wind noise). This may be a substantial motive in homes close to an external noise source.

Filling small air gaps can also reduce the amount of dirt blowing in, which causes staining around gaps in the envelope, or odours from outdoors.

In some locations, the benefit is multiplied by combinations of noise, wind, dirt and odours (e.g. close to motorways or some factories or farms).

Draughtproofing can sometimes be an added benefit to having a new carpet (or other flooring) fitted, as the carpet then acts as a draughtproofing measure unintentionally. However, draughtproofing before the flooring is laid will give it some protection from dust, dirt or lifting in the wind. Similarly, draughtproofing can come 'free' with new windows and doors or external wall insulation.

For some people, draughtproofing creates a barrier between the previously noisy outdoors and the environment within their home. Therefore draughtproofing might offer a feeling of greater security.

- (g) *Improve aesthetics*

This is unlikely to be a strong motivating factor. However, where curtains are invoked as part of the draughtproofing strategy, there is an element of making the home feel cosy.

- (h) *Feel good about yourself*

There may be a certain degree of self-image and pride in draughtproofing, however, this is likely to be minimal as the means is largely invisible unless the wind had previously been whistling through the home. The fact that it is largely a DIY job may, however, create some satisfaction with developing personal competence.

- (i) *Make my life easier*

This is not a key motivation, although the maintenance of a more even temperature may have some benefits, e.g. in terms of reducing the need to adjust the heating.

Opportunity

The financial cost is relatively low compared with other energy saving measures; however, it does require time, in locating the areas that need draughtproofing, purchasing the materials and installing them. Tenants may benefit from a short payback time, especially if they arrange for the landlord to pay for materials.

To overcome the issue of time some simple, quick ways to highlight those areas causing the most energy loss should be part of the explanation.

Another barrier may be that people are not acutely aware of a building being leaky and so do not feel the need to draughtproof despite the fact the house is wasting energy. Hence, taking time to check is important.

Solid wall insulation

Summary of change

Energy demand for space heating is reduced by insulating external solid walls to reduce heat loss by conduction and air leakage (see also “Draughtproofing”).

Potential CO₂ benefit

External solid wall insulation could save around 2.1 tonnes of CO₂ per year for a typical three bedroom semi-detached house with solid brick walls making up all three external facades. This assumes the home is not heated to a higher temperature or for longer hours or in more rooms following the insulation.

MMO Analysis

Means

Heat loss through solid external walls can be reduced by adding insulation to either the internal or external surface of the wall. “Solid wall insulation” is perhaps a misnomer since the same measures can be applied to cavity walls if additional insulation is desired.

External insulation is the prime consideration here because internal insulation, although generally cheaper:

- is generally less effective (e.g. because of thermal bridging);
- reduces the cooling benefit of thermal mass, thus possibly creating a need for air conditioning (now or in future);
- reduces the size of the rooms insulated (less so with some recently developed materials that can be effective at only 10 mm thick);
- risks damage to the wall by interstitial condensation;
- is prone to failure if the required vapour barrier is not properly installed or is later punctured;
- requires redecoration and often refitting of interior features after installation (especially in kitchens and bathrooms);
- makes it more difficult to attach interior fittings taking a significant load to the wall.

External insulation also faces some difficulties, mainly related to appearance (although this is now being addressed with surfaces that resemble brick, for example), external space (e.g. if there is a narrow alley outside the home), whether the roof line extends far enough and refitting exterior items such as satellite dishes and rainwater goods. Also, planning permission may be required for external wall insulation, particularly in conservation areas.

The long-term advantages make it worth overcoming these problems.

There is a case for mixed methods so that, for example, the front of the house has internal insulation if the external appearance would otherwise be unacceptable but the rear and sides (less sensitive and where kitchens and bathrooms are generally located) have external insulation.

A simple supplementary measure that anyone can take is to fit sheets of insulating reflective material between radiators and external walls.

Guidance would need to focus on:

- whether the property is suitable for this type of insulation, i.e. its external walls are solid, and structurally sound;
- the likely benefits, including quantification of the financial savings and reduction in CO₂ emissions;
- the desirability of adjacent homes being treated at the same time, to reduce cost and maintain consistency of appearance;
- how to get the insulation installed (generally requiring professional installers) and information regarding typical costs and the length of time it takes to complete;
- the various options available, covering combinations of insulation and finishing materials.

Motive

(a) *Save the planet*

(b) *Save the country*

(c) *Save me*

All three apply. Some people may find it difficult to create a mental link between having their solid walls insulated and saving the planet but the high cost might, in some cases, make this link easier to conceive.

(d) *Save (or make) money*

This applies, but needs to be presented well because the initial cost is considerably larger in comparison to many other measures (particularly cavity wall insulation). Despite this, the potential annual savings are also significant and good quality external wall insulation has a long life and can reduce the need for maintenance. Therefore it would need to be pitched in such a way that homeowners do not immediately dismiss it on the grounds of initial expense. This will be easier if the walls are in need of repair anyway.

There may also be some direct benefit on resale or rental value of the home if the exterior finish is attractive to people for non-energy reasons, in addition to the increasing influence of Energy Performance Certificates.

(e) Avoid waste

This may be a motivating factor, as clearly energy will be saved.

(f) Wellbeing: be healthy, comfortable, safe and productive

External solid wall insulation provides an enduring improvement in insulation through both the winter and summer, i.e. it retains heat during the heating season but also reduces solar incidental gains through the wall during hotter months. It thus helps to maintain a comfortable temperature within the home throughout the year. It can also increase airtightness, which reduces draughts, and thermal bridging, reducing the risk of condensation.

Depending on the thickness and design of the insulation, there may also be some shading of windows, reducing risk of overheating in summer but similarly reducing incidental heat gains in winter. This would not be the case if the windows were relocated to fit the new external surface but this would provide the alternative benefit of creating wider window sills.

Safety is unlikely to be relevant unless the external insulation is part of other refurbishments that are being undertaken to make the walls more structurally sound.

(g) Improve aesthetics

(h) Feel good about yourself

The relevance of these motives will depend on perceptions of how the new look of the home compares with the original look and/or with surrounding homes. Awareness of the full range of

possible finishing materials is therefore likely to be important and, conversely, retrofit is likely to be most attractive where the existing walls are in poor repair and/or considered unattractive, and/or where a row of houses or complete block of flats is treated at the same time.

The change in appearance of the property can equally be a barrier, particularly in the case of listed buildings and 'period properties' generally.

(i) Make my life easier

This is not a key motivating factor although the maintenance of a more even temperature may have some benefits, e.g. in terms of reducing the need to adjust the heating.

Opportunity

The most significant barriers to opportunity will be the cost and, to a lesser extent, the time needed to select the right approach and installer. In some cases, a lack of exterior space may be prohibitive.

To overcome the barrier of cost, emphasis could be placed on the energy savings, potential marginal cost if the exterior already requires repair or refurbishment and opportunity to obtain a low maintenance finish. It may be also more cost effective to install solid wall insulation when other major refurbishment or building work is planned, as scaffolding, etc. is already in place. Also, this concentrates major disruption into a single period.

The time and cost barriers can both be reduced by local or central government or other organisations assisting with selection of approach and installer, and negotiating the best price for multiple installations in an area. Tenants are likely to benefit from such schemes whereas they are unlikely to pay the high capital cost themselves.

In extreme cases, external insulation may save money by allowing an estate to be renovated rather than demolished.

Cavity wall insulation

Summary of change

Energy demand for space heating is reduced by filling cavities in external walls and walls between heated and unheated spaces (e.g. garages).

Potential CO₂ benefit

Savings from reduced heat loss are of the order of 600-900 kg of CO₂ per year, assuming the home is not then heated to a higher temperature or for longer hours or in more rooms.

MMO Analysis

Means

Cavity walls are insulated during construction by situating insulating material in the cavity as the wall is built. Alternatively, in new or existing homes, loose or foamed insulation can be injected into the cavity through holes drilled through the outer leaf of the wall (or the inner leaf prior to plastering). Retrofit insulation is generally complete within a day and is relatively inexpensive with immediate financial savings and a short payback period.

Materials are typically mineral fibre or rigid foam board although polystyrene and other foamed insulants have been used. Urea formaldehyde foam (U-foam) was popular as a lower cost alternative at one point but it suffers the deficiency of sometimes cracking as it dries, leaving thermal bridges. There were also concerns, largely unfounded, about releasing formaldehyde into the air inside the building.

Advice and guidance on cavity wall insulation is widely available, often linked to grant schemes to support installation, and to installers associated with the scheme. Cavity wall insulation is a job for a competent installer, who may be registered as a member of, for example, the National Insulation Association (NIA), The Cavity Insulation Guarantee Agency (CIGA) or The British Board of Agreement (BBA).

Being a professional job, detailed guidance for the public is generally neither available nor necessary but there could be better guidance on how to know whether a wall is already insulated or is suitable for insulation. Not all walls have cavities and even those that do may not be suitable for insulation, depending on the materials used and the condition of the wall (e.g. damage or dampness). Where there is excessive wind-driven rain, walls may need external protection (e.g. by rendering) to prevent rainwater bridging the cavity and affecting

the insulating material and the inner leaf of the wall.

Apart from the above basic information, guidance would need to focus upon the simplicity and safety of the process and the various benefits. The explanation might also promote the opportunity if users discover that the installation of cavity wall insulation is not as expensive or time-consuming as they had thought.

Information should also cover caveats such as the appropriate order for different interventions, e.g. if the householder proposes replacing windows, this should ideally be done before insulating the cavity wall if the cavities are exposed at any point around the windows.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All apply but, as with other routine and invisible changes, some people may find it difficult to create a mental link between having their cavity walls insulated and saving the planet.

- (d) *Save (or make) money*
- (e) *Avoid waste*

Likely to be significant motives because the capital cost is relatively low, the material lasts an indefinite period (installation should be guaranteed for 25 years) and there is no maintenance. This, together with the short payback period and wide availability of grants, is sufficient for many householders and managers of property.

The direct benefit on resale or rental value of the home is probably low but, with the increasing influence of Energy Performance Certificates, the contribution to overall energy efficiency will have some benefit at the point of sale or rental.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

The reduction in heat loss will make it easier to maintain a warm home and/or keep more rooms warm and usable. Making the inner surface of the wall warmer also reduces the risk of condensation and mould.

To a limited extent, cavity insulation also reduces the risk of overheating in summer when the outer leaf of the wall is heated by the sun.

(g) Improve aesthetics

This motive is not relevant.

(h) Feel good about yourself

Unlikely to be significant in most cases except at the most general level – the measure is not visible (except during installation) or exceptional.

(i) Make my life easier

This is not a key motivation, although the maintenance of a more even temperature may have some benefits, e.g. in terms of reducing the need to adjust the heating.

Opportunity

Money may act as a barrier but, to overcome this, there are grants and offers available to help pay

for cavity wall insulation. Subsidies are available from energy suppliers under the Carbon Emissions Reduction Target (CERT) and tenants can use this to encourage landlords to undertake the insulation. With such subsidies, it may even be financially worthwhile for tenants to pay at least some of the cost themselves.

Time is not likely to be significant, as the installation process does not usually take longer than a few hours but this point would need to be well publicised. In some cases, householders may need to take a little time to ensure there is sufficient access to the wall all around the home and to warn neighbours there will be some noise during installation.

Insulation of loft or roof

Summary of change

Energy demand for space heating is reduced by installing loft or roof insulation to reduce heat loss. The extent of the benefits will be dependent upon the thickness of the insulation installed, the area covered, the material used and whether it is a combination of loft and roof insulation or just one of those options.

Potential CO₂ benefit

A saving of around 800-1000 kg of CO₂ per year could be generated by adding 270 mm of mineral fibre insulation to an uninsulated loft floor. If there is already 50 mm of insulation, topping this up to 270 mm could save around 250 kg per year. This assumes the home is not heated to a higher temperature or for longer hours or in more rooms following the insulation.

MMO Analysis

Means

The means, in simple terms, would be to insulate the loft or roof to reduce heat loss from the building, with the possibility also of reducing air leakage through the roof (see also "Draughtproofing").

Establishing the means will entail publicising a clear explanation to potential users of the different options, focusing on significant reduction in wasted heat and money, the other benefits and how simple it is to do.

The most common method is to place insulation on the floor of the loft, to a depth of up to about 270 mm. Mineral fibre in rolls is the most common material but others are loose mineral fibre, cellulose, hemp and sheep's wool. This can be a DIY job but there are also professionals and volunteers who provide the service. Loose materials, blown into the loft, are more suitable where access to the loft is difficult.

Alternatively, insulation can be fitted in the roof itself – in a flat roof or between the rafters of a pitched roof. In some cases there is the option of providing better insulation by converting a flat roof to a pitched roof. These are generally professional jobs and not DIY tasks.

Insulating a flat roof will be more cost effective and less disruptive if done when other work is needed, for example when redecorating the room or repairing the ceiling (if the insulation is to be internal) or when waterproof covering is replaced (if the insulation is to be external).

Insulating between the rafters is more common where there is no loft space or where the loft is used as living space and so a 'warm roof' is desired. Because the insulation is likely to be thinner, materials with lower conductivity are more likely to be used (e.g. foamed insulation).

The thickness of the insulation needs to be adapted to the particular space and the use made of it. In theory, thicker insulation is better but insisting on the full thickness over the whole area in every case may be counterproductive. Not all occupants will accept it or retain it after the installers have gone. Some occupants may compress the insulation by boarding over it; 270 mm compressed to 100 mm is not as effective as laying 100 mm. It is also important not to create a hazard by making it impossible to see the joists when moving about the loft.

For these reasons, in some cases it may be more cost-effective to use a thinner, more expensive material to achieve the same insulation, or to combine insulation of the loft floor with insulation of the roof. Where there is sufficient head height, it is also possible to have both a usable loft floor and extra insulation by cross-laying joists (i.e. insulate to the top of the existing joists, add a second set of joists at right angles and insulate between these too, then fit flooring to the upper joists).

Other risks are as follows - these need to be managed and not become a barrier to insulating.

- Blocking all ventilation to the roof space can cause condensation and damp.
- Water tanks can freeze, and possible rupture, if the floor directly beneath them is insulated.
- The loft will be colder so water pipes running through it will lose more heat and they need to be better insulated to avoid pipe bursts and (in the case of hot pipes) wasted energy.
- During installation, there are potential risks to the installers from temporary mild irritation of the skin and airways, heat (in summer) or cold (in winter), colliding with rafters or falling through the ceiling. These risks are easily managed if the installer is aware of them.

Some people wrongly associate mineral fibre with asbestos, which is a well known health hazard, so this will need to be countered where it arises.

A 'green roof' is popular in some high profile developments and conversions but generally not available for 'ordinary' homes.

Motive

(a) *Save the planet*

(b) *Save the country*

(c) *Save my household*

All three apply but loft insulation is such a common feature now in the UK that some users may find it difficult to create a mental link with saving the planet.

(d) *Save (or make) money*

This is likely to be the most significant motive. This is because the initial cost is relatively low and there is a quick payback period. This motive may be greater if hot water pipes run across the loft floor because of the possibility of saving more energy and money by placing insulation above the pipes.

The direct benefit on resale or rental value of the home is probably low but, with the increasing influence of Energy Performance Certificates, the contribution to overall energy efficiency will have some benefit at the point of sale or rental.

(e) *Avoid waste*

This is a motive, as energy use is reduced.

(f) *Wellbeing: be healthy, comfortable, safe and productive*

This is likely to be applicable for many people choosing to insulate their roof for non-energy related reasons.

- Improving thermal comfort is likely to be the key reason.
- Comfort will also include, for some occupants, a reduction in noise from the roof space or from outside.
- Insulating the loft will mean the upper floor ceiling will be warmer so there will be less risk of condensation and mould.

(g) *Improve aesthetics*

This is not likely to play an influential role.

(h) *Feel good about yourself*

Loft insulation is common and not itself highly visible so this motive may not be of great importance. However, a poorly insulated loft or roof space can be very evident, for example when it snows (snow on the roof melts faster) and this may be influential as a source of embarrassment if it becomes obvious that the household is wasting energy.

Some people may get a sense of satisfaction or personal competence from installing the insulation themselves.

A feeling of reduced energy dependency may be influential on the margins for some people but is not likely to be a significant motivator all round.

(i) *Make my life easier*

This may have a negative impact, as some storage space may become unavailable (for example if boards cannot be laid because of the thickness of insulation). This may be partially balanced by the maintenance of a more even temperature reducing the need to adjust the heating.

Opportunity

The cost is generally low and the payback period short, and the effective cost is reduced if only top-up insulation is required. Nevertheless, for people who have very little money it is still a cost that is not seen as an absolutely necessary for their day-to-day-lives. Cost will be greater if the homeowner does not have the skill, confidence or mobility to carry out the installation, or no means of getting materials home from the store.

Opportunity issues are more likely to arise around time, space and a degree of inertia about doing the work. For some people, loft insulation may come across as a large task, particularly if the loft is currently being used for storage: it takes time to move items temporarily (or sometimes to sort items out for disposal or find somewhere else altogether to store them).

Hence, clearing the loft may be a greater barrier than laying the insulation. This is sometimes expressed as a belief that the loft does not need to be insulated because there is enough 'junk' there to do the job, or the home is already warm enough and so does not need insulation. The time factor is likely to be more salient if the loft has already been cleared once to put in less insulation than currently recommended and the householder does not see great value in topping up.

Taking all this into account, the ideal time to promote loft insulation would be when a household moves into a new home. There may also be an opportunity when other major disruptions are occurring.

The costs are probably on the edge of what tenants would be prepared to pay for although deals can be made with landlords for them to pay and the tenant to do the work. Combined with grants and landlord tax incentives, there is probably no great reason for tenants to be disadvantaged.

Floor insulation

Summary of change

Energy demand for space heating would be reduced by installing an appropriate form of insulation within or beneath the floor. This applies to ground floors and any other floors above an unheated space (e.g. an integral garage). In some cases, depending on the type of insulation and type of floor, there would be additional benefit from reduction of air leakage (see also “Draughtproofing”).

Potential CO₂ benefit

Floor insulation can generate an annual saving of approximately 270 kg CO₂ assuming the home is not heated to a higher temperature or for longer hours or in more rooms following the insulation.

MMO Analysis

Means

In the case of suspended timber floors, retrofit is easy and relatively inexpensive. It can be achieved by lifting the floorboards and laying mineral fibre insulation, supported by plastic netting, between the joists. In some cases, it may be possible to carry out the work from a crawl-space under the floor, without lifting the floorboards.

Risks are minimal and mainly concern ventilation of timber floors to protect from moisture damage; in particular, airbricks in outside walls and ventilation gaps under internal walls must not be blocked. Therefore, guidance should be clear and accessible to ensure occupants are not only aware of it but also have sufficient knowledge of how to implement the means effectively.

Where there is a solid concrete floor, insulation is easily provided during construction and generally takes the form of polystyrene beneath the top layer of concrete. Retrofit is more disruptive and costly, requiring break-up of the floor or laying a supplementary layer above. The latter would reduce the ceiling height and require adjustment to any adjacent stair in order to maintain constant riser heights.

Information would need to focus upon the risks and:

- which form of insulation is most appropriate for the type of floor;
- correct DIY installation and where to purchase materials or how to get professional installation;
- clear information on situations where professional installation may be necessary;

- opportunities to install insulation with minimum disruption and cost (e.g. during renovation works such as rewiring or when carpets are being replaced).

Engaging intermediaries such as builders and carpet sellers to communicate information on floor insulation is an opportunity to raise general awareness of the measure.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save me*

All apply although, as with other routine and invisible means, people may not easily make the more distant connections such as saving the planet.

- (d) *Save (or make) money*
- (e) *Avoid waste*

Saving money will be clearer for insulation of suspended timber floors, especially if done as part of other works. Some occupants may see an additional financial advantage if they find they no longer need to have a carpet, the floor being warmer and less draughty.

The direct benefit on resale or rental value of the home is probably low but, with the increasing influence of Energy Performance Certificates, the contribution to overall energy efficiency will have some benefit at the point of sale or rental.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

Apart from making it generally easier to keep warm, some people will appreciate having a warmer (possibly less draughty) floor, especially if they walk in bare feet and/or do not have a carpet on the floor. Some people may have wanted to take out carpets (e.g. because of allergy risks or dust problems) but been held back by the cold or draughty floor; insulating the floor might remove this barrier to taking an action for reasons of health.

In some cases, occupants may perceive less noise transmission, either from the outside (through airbricks) or from neighbouring homes with an air path at subfloor level. In the process of lifting and refitting flooring, there is also an opportunity to eliminate any creaking or excessive movement in the boards or other floor material. People are unlikely to make these connections and they are therefore worth pointing out where relevant.

Where there is a habitable space above a garage, insulation can be encouraged alongside sealing the floor to prevent ingress of gases and vapours from vehicles and materials kept in the garage. Again, the connection between the two may not be obvious and will need to be pointed out where relevant.

(g) Improve aesthetics

This may be a relevant motive if the householder would like to remove carpets for aesthetic reasons, but has been deterred by draughts.

(h) Feel good about yourself

This is unlikely to be a significant motive for a generally simple and invisible measure although some people may take some pride in developing or demonstrating a DIY skill.

(i) Make my life easier

This is not a key motivating factor for this behaviour, although the maintenance of a more even temperature may have some benefits, e.g. in terms of reducing the need to adjust the heating.

Opportunity

Opportunity issues are likely to arise around money and time but a major barrier is also likely to be lack of awareness of the option of insulating floors (it tends not to be part of major campaigns) or the DIY opportunity.

As with many retrofit measures, expense and time demands can be reduced markedly by being opportunistic about timing: doing the work when first moving in to a property or when the floor or carpet is lifted for other reasons (e.g. when floorboards need to be replaced, if a solid floor needs to be taken up for repair or damp-proofing, during re-wiring or when fitting plumbing or communications cables beneath the floor, or when installing under-floor heating). Even choosing a

time when carpets or other floor coverings need to be replaced will reduce time and cost demands.

To ensure the means is realised and that the public is aware of it, there needs to be clear and accessible information to promote the benefits and opportunity, alongside more well known means such as loft insulation.

The cost of materials for insulating suspended timber floors is relatively low. One or two days of professional labour would add to the cost but not greatly.

The work is feasible for someone who is reasonably competent in DIY with clear guidance on the installation but then time becomes a greater factor. Lifting floorboards, laying the insulation, and relaying the floorboards in the correct positions is time-consuming, but not prohibitively so, especially with clear guidance. The amount of work is reduced where it is possible to carry out the work from a crawl-space under the floor, but the work may be less comfortable.

Retrofit insulation of a solid floor is generally more time-consuming, disruptive and expensive, requiring professional labour and equipment hire. It can, nevertheless, be a viable investment because of the long life of a floor.

One option is to identify those rooms that generate the largest loss of energy (or feel the coldest) and insulate those rooms first, to keep costs down and make them more manageable.

As with many of the other changes that involve alteration to the fabric of the building, tenants are less likely to make the change. They could, however, take advantage of renovations being done by the landlord to suggest the small additional cost of floor insulation (especially if the tenant supplies the labour).

Multiple glazing

Summary of change

Energy demand for space heating would be reduced by installing double glazing or other multiple glazing to replace less energy-efficient windows (and possibly also doors). The reduction in heat loss would result from a combination of increasing insulation and (often) reducing air leakage (see also "Draughtproofing"). The benefit would be increased by using refinements such as dense gas in the inter-pane space and low emissivity glass.

Potential CO₂ benefit

Double glazing cuts heat lost through windows by around half, depending on the exact specification and what it is replacing. Installing Energy Saving Recommended double glazing can reduce CO₂ emission by around 720 kg per year.

MMO Analysis

Means

The means, in simple terms, would be to have new glazing fitted to reduce heat loss from the building. Establishing the means will require clearly explaining to potential users the various glazing options, emphasising:

- the significant savings that can be made in energy and money;
- relative costs and benefits (and payback period) of different multiple glazing options;
- the possible need for planning permission, and information on secondary glazing if new windows are not permitted (e.g. in some listed buildings);
- additional benefits (e.g. for noise and security) but with a difference between optimum design for acoustic and thermal insulation;¹⁷
- appropriate designs of windows for good summer ventilation (see "Adaptive use of windows and ventilation");
- caveats regarding the appropriate order for different measures to be installed (e.g. fit new windows before insulating cavity walls).

There should also be advice on the use of double glazing, once installed (see also "Adaptive use of windows and ventilation").

The explanation might also create opportunity if users discover that double glazing is not as

expensive or time-consuming as they had initially thought, or if it leads to awareness of subsidies.

Risks that need to be avoided are:

- making a building too airtight for minimum levels of ventilation to be achieved as before;
- eliminating small opening lights that provide ventilation with security;
- preventing escape in case of fire or other emergency;
- replacing windows in a way that increases net CO₂ emissions (e.g. because the savings in use do not outweigh the embedded energy);
- release of combustion products from uPVC (or long-term consignment to landfill) at end of life.

Conservatories can present a problem: large exposed areas of glazing, and hence a potential for substantial heat loss (or overheating in summer), but with a high cost of replacement. Householders should be advised on the best available technology for glazing conservatories, and the relative costs of different solutions.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All three apply but double glazing is such a common feature now in the UK that some users may find it difficult to see the connection between changing their windows and saving the planet. However, for single glazed properties, the benefits are clear.

- (d) *Save (or make) money*
- (e) *Avoid waste*

Saving money is likely to be applicable as people will associate saving energy with saving on their energy bills. However, the relatively large capital cost may act as a barrier to this motive, and payback times may be long. For this reason, avoiding waste may be a stronger argument.

The capital cost will be mitigated if the existing windows are in need of replacement and the effective cost is therefore only the difference between replacing with single-glazed windows and upgrading to multiple panes.

There is also some direct benefit on resale or rental value of the home because the measure is generally attractive to people for non-energy reasons, in addition to the increasing influence of Energy Performance Certificates.

¹⁷ Acoustic insulation is more effective with larger spaces between panes than is optimal for thermal insulation.

(f) Wellbeing: be healthy, comfortable, safe and productive

This is likely to be the most significant motive for many and a good route to engage people who are not otherwise interested in energy or climate change. The following are possible specific motives.

- Improving thermal comfort, especially when close to the windows, because double generally eliminates drafts and removes a cold surface, i.e. sitting next to a single-glazed window is colder than sitting next to a double-glazed window.
- Comfort will also include, for some occupants, the reduction in noise from outside (and possibly also the freedom to make more noise inside).
- Improving comfort could also make a building functionally larger than it was previously by making certain rooms thermally and/or acoustically more usable.

In circumstances where noise is the main motive, promoting triple glazing would be a potential route to take, or double glazing with external shutters to act as a barrier to noise. The benefits of shutters alongside double glazing may also be promoted, such as the additional control on the temperature of the building (i.e. closed shutters keep a room cooler during the summer), improvement in security and possibly aesthetic improvements (see “Adaptive use of windows and ventilation”).

Security may also be important for some, for example where there is a high rate of burglary. Multiple glazing itself is generally more difficult to break because the air cushion between the panes makes the window stronger (and this can be enhanced further by using toughened or laminated glass). Frames, locks, security catches, and the size and location of opening lights can be selected to enhance security.

For similar reasons, safety can also be enhanced. Also, above ground floor level, new windows can be safer to maintain (uPVC frames require maintenance less often than painted wood frames) and clean (often being double hinged so the outside can be cleaned from inside).

(g) Improve aesthetics

(h) Feel good about yourself

Multiple glazing is one of the more visible and recognisable energy efficiency measures, and is generally (though not always) seen as an aesthetic improvement). It hence has potential to improve

self esteem and increase pride in the neighbourhood.

(i) Make my life easier

This is a relevant motivating factor as new windows can be easier to maintain and clean, as noted above in discussing security and safety benefits. In addition, the maintenance of a more even temperature may have some benefits, e.g. in terms of reducing the need to adjust the heating.

Opportunity

Opportunity issues are likely to arise around both cost and time:

- the time it takes to chose the windows and an installation company;
- large cost to have them installed;
- time to manage the installation, i.e. be at home whilst they are being installed, and possibly to redecorate afterwards.

To overcome these barriers, some or all of the following may be relevant.

- As noted earlier, the effective cost is reduced if double glazing is installed when the existing windows need to be replaced.
- Householders could consider the benefits of having the windows changed only in those rooms that cost the most to heat.
- When moving to a new property, fit new windows before decorating.
- There may be a reduction in home insurance and maintenance costs, in addition to a reduction in energy bills.

Because of the capital cost, replacing windows is unlikely to be attractive to tenants in the absence of financial systems to pass on a large proportion of the cost to the landlord or future tenants. To overcome this barrier, it would also help to have incentives for landlords. Information on such incentives would need to be incorporated into information on double glazing so as not to immediately exclude consideration by tenants who would need to influence their landlords. The benefits to the landlord (e.g. higher rent and/or reduced void time) would need to be clearly conveyed and easily accessible.

Where a householder is already conducting significant works that require scaffolding (e.g. alterations to the roof, painting or rendering walls or fitting solid wall insulation), it may be cost-effective to fit new windows at the same time, as scaffolding is needed for both.

Installing a new boiler

Summary of change

CO₂ emissions from space and water heating would be reduced by replacing an old/inefficient boiler (or a direct electric system) with one that is more efficient (e.g. a gas condensing boiler¹⁸) and/or uses a renewable fuel (e.g. biomass). Savings would be greater where the same boiler provided both domestic hot water and heating, as is generally the case.

Potential CO₂ benefit

Around 60% of CO₂ emissions from the home are down to the boiler providing heat and hot water. With an efficient new boiler there is the potential to save up to 1 tonne of CO₂ per year. The benefit is enhanced by ensuring good control of the temperature of water and rooms, and the timing of boiler operation (see "Heating controls" and "Control and use of domestic hot water").

MMO Analysis

Means

The means would be to replace an inefficient boiler (or other source of heat) with a new, more efficient boiler. The most common approach is to install a gas condensing boiler but the net CO₂ savings can be greater where a renewable fuel is used, as in a biomass boiler. Where a new gas boiler is being fitted, regulations effectively require that it is a condensing boiler. Many households now prefer a combi condensing boiler, which does not store water and therefore does not waste energy as stored water cools. But supplementing the boiler with solar thermal heating will require a hot water storage vessel. If such a vessel is being fitted or replaced, it makes sense to fit one with two heating coils so that, in the future, a solar thermal system can be connected more easily and at substantially lower cost.

Gas condensing boilers are likely to be the majority choice because they are less expensive, easily fitted, respond quickly to changing demands and, unlike biomass boilers, have the convenience of mains source fuel rather than needing to order, store and feed fuel to the appliance. There are also, at present, only a few suppliers of the usual fuel for biomass boilers, i.e. wood pellets. Other fuels can be used but wood pellets are convenient (because they can be fed automatically to the boiler from a hopper). There is also consideration of allowing them to be used in Smoke Control Areas ('smokeless zones').

The full efficiency of boilers is realised only if they are correctly installed and commissioned; this can mean siting the boiler in a different location to the old boiler. They also need to be operated at optimum water temperature, which should be clearly explained to purchasers and users. Information needs would also include:

- the benefits with replacing old, inefficient boilers, covering the key motive points;
- the importance of additional improvements to heating and hot water systems to make the most of the new boiler (e.g. insulating hot water pipes and any hot water storage vessel and ensuring there are appropriate timing and thermostatic controls).

Replacing a boiler should be considered alongside other options for providing or supplementing hot water and/or heating (e.g. solar thermal water heating, heat pumps, combined heat and power systems and district heating).

There are other technologies that are being kept under review (e.g. fuel cells and centrally optimised direct electric heating systems).

It is also worth noting that a well insulated airtight home may not need a heating system at all, being capable of maintaining a comfortable temperature using incidental heat gains (e.g. from people, appliances and heat from the sun) and mechanical ventilation with heat recovery (see "Adaptive use of windows and ventilation").

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*
- (d) *Save (or make) money*

All four of these general motives apply but there is a risk of a rebound effect when users get more hot water for their money (e.g. taking more baths or longer showers, or heating the home for longer, in more rooms or to a higher temperature).

Depending on the initial situation, such responses may be rational and reasonable but guidance needs to discourage excesses.

Biomass boilers may be more appealing for those motivated by national energy security (there is a limited stock of natural gas – in the UK and globally) or a desire for personal energy security (i.e. the fuel can be stockpiled to guard against short-term failure of supply). The use of local wood can also generate and secure local jobs, ensuring money spent is kept within the local economy, although this would not be a common benefit at

¹⁸ <http://britishgas.boiler-systems.co.uk/condensing-boilers/>

present. Some users may alternatively have concerns over loss of woods and forests, which would need to be addressed in guidance.

A new boiler can have some direct benefit on resale or rental value of the home because of the prospect that it will not need to be replaced for some time (particularly with warranties now being commonly for five years), in addition to the increasing influence of Energy Performance Certificates.

(e) Avoid waste

This could have a negative motivation for some people, as they see the replacement of a working boiler as wasteful (even though it may be less efficient). Information on the life cycle cost of a boiler in relation to the energy saved would help with this.

(f) Wellbeing: be healthy, comfortable, safe and productive

In some cases, a replacement boiler will allow people to achieve healthy, comfortable temperatures that were not affordable before; this may be the dominant motive among those making the change for non-energy reasons. Some may also see a benefit in having a quieter boiler and/or relocating the boiler in a room where noise and space are less of an issue.

A biomass boiler requires space for the boiler itself and a dry area for the storage of biomass fuel and this may be an absolute or perceived barrier for some, because of the loss of amenity, taking up valuable space in the home or garden. Smoke from the boiler may also be a concern, depending on its location.

The relevance of safety will depend on what the new boiler is replacing, but the home may become safer if the existing boiler or other heat source creates a risk of:

- carbon monoxide poisoning (e.g. because of a faulty or incorrectly located open flue);
- explosion (as with some older unvented hot water systems, or from gas fuel leakage);
- fire.

(g) Improve aesthetics

This is unlikely to be a strong motivating factor unless replacing an old boiler would offer the chance to install in a more out-of-sight location.

(h) Feel good about yourself

Any new, visible and expensive item in the home has the potential to arouse this motive but the

more unusual option (biomass boiler) may create a greater sense of:

- partially fulfilling a desire for self-sufficiency;
- association with role models (as portrayed in TV programmes on 'ecohomes').

(i) Make my life easier

This motive may be relevant, as timely replacement of a boiler avoids the inconvenience of a boiler breaking down and depriving the household of heating and hot water.

In the case of biomass boilers, there may be a perceived barrier in the handling of the fuel, especially in the case of householders with a physical disability.

Opportunity

For gas condensing boilers, the main opportunity issue is likely to be the cost since sourcing and installing are relatively straightforward. For biomass boilers there are a number of additional opportunity issues:

- the space needed next to the boiler to store the fuel;
- a new flue may be required;
- Building Regulations and/or safety approval may be needed;
- biomass cannot be burnt in smokeless zones unless the appliance is exempted;
- planning permission may be required, depending on the location of the boiler and the height of the flue.

However, cheaper fuel (gas or wood pellets cost less than electricity or LPG), combined with efficiency gains, will offer sufficient cost saving to justify the investment.

Because of the capital cost, replacing a boiler is unlikely to be attractive to tenants in the absence of financial systems to pass on a proportion of the cost to the landlord or future tenants. To overcome this barrier, it would also help to have incentives for landlords so that, when a boiler needs to be replaced, they select an efficient one. They are already required to fit a condensing boiler if installing a gas boiler so this is covered to some extent. Any improvement on this is likely to depend on pressure from tenants and information on the various reasons for selecting the most efficient available boiler.

Installing a heat pump

Summary of change

Energy demand for space heating would be reduced by installing a heat pump into a new home or to replace an existing boiler. New, larger radiators may also be required, or an under-floor heat distribution system. The cost effectiveness of heat pumps is further increased by improving the energy efficiency of the home first as they are most efficient when used in highly insulated buildings.

Potential CO₂ benefit

A typical ground source heat pump reduces CO₂ emissions substantially, the exact amount depending on what it is replacing - around 7 tonnes of CO₂ every year if displacing electric heating, 6.5 tonnes if displacing solid fuel, 1.8 tonnes if displacing oil-fired central heating and 1.2 tonnes if displacing natural gas.¹⁹ CO₂ savings are generally less for air source heat pumps.

CO₂ emissions can be further reduced if the compressor and pump are supplied in part by solar power or some other renewable source.

MMO Analysis

Means

The means would be to have a ground source, air source or water source heat pump to reduce energy demand for space and water heating. However, the following limitations must be noted.

- Heat pumps are most efficient when used in highly insulated buildings, therefore reducing draughts, improving insulation and the control of heating and hot water systems are recommended prior measures.
- Heat pumps work better with low temperature heating systems such as under-floor heating or large surface area radiators, rather than conventional radiators.
- Most domestic systems use a ground-based heat source; this requires a trench or borehole for heat collection, therefore a large area of outdoor space or a deep hole. A borehole is generally second choice because it tends to be more expensive.
- An air source heat pump would be the realistic alternative in most cases (i.e. where there is not a convenient water source) but these generally perform better at warmer air temperatures: they need supplementary

heating if the air temperature is below 5°C or to achieve heated water temperatures of 55°C or more.

- Ground and water source heat pumps are Permitted Developments (except in listed buildings) whereas air source heat pumps are not, therefore requiring consultation with the local authority regarding planning permission.
- Heat pumps need high electric currents to start up and some electricity supplies may not be sufficient for this task, although this is a lesser problem with more recent designs that have 'soft start'.
- Householders must be made aware of the electricity requirement of a heat pump, so that they are not surprised by possible increases in electricity usage.
- Heat pumps may require more maintenance and parts replacement, and have a shorter life, than a standard boiler. This is because they are more complicated systems with higher number of components, many of which are highly stressed.

Establishing the means would therefore entail publicising a clear explanation to potential users (as the Energy Saving Trust already offers), focusing on the relative cost and benefits of each source, i.e. ground, air or water, and the most appropriate system for each user.

Heat pumps are expensive items, so householders should be encouraged to consider them as part of a 'whole house' energy hierarchy approach where demand reduction measures (such as insulation) and more cost effective heating measures (such as condensing boilers) are considered first.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All three apply, and are likely to be significant for this means as, at this stage in its development, users interested in installing this technology are likely to be environmentally conscious already and will be serious about taking opportunities to reduce CO₂ emissions. The possibility of having an almost carbon-neutral energy supply (if combined with electricity from renewable sources) is likely to be particularly attractive. Households not on the gas grid may find the option particularly attractive.

- (d) *Save (or make) money*

This may be applicable, through a combination of saving on energy bills and an expected service life

¹⁹ These savings assume ground source heat pump installed in a detached property and providing up to 50% of domestic hot water as well as 100% of space heating.

of 20 years for the plant. However, the electricity used to start and run heat pumps must be taken into account, especially where this is not being generated from renewable sources.

The large capital cost is likely to be a major barrier. In new build, or if major renovations (including replacement of a heating system) are due to take place, then the capital cost could be mitigated as the effective cost would be the difference between replacing or repairing the existing system and installing a heat pump.

There may also be some direct benefit on resale or rental value of the home because of some combination of low energy costs and the novelty of the technology, in addition to the increasing influence of Energy Performance Certificates.

(e) Avoid waste

This is not likely to be a strong motivating factor until gas and other fossil fuels are more widely recognised as a finite resource.

(f) Wellbeing: be healthy, comfortable, safe and productive

This motive will be most relevant where under-floor heating is part of the package, although this is not a necessary part of installing a heat pump – some people prefer this kind of heating.

The lower running costs could, in principle, also enable the home to be kept warmer. However, this is unlikely to apply in practice to a household that can afford a retrofit heat pump. There could be an indirect benefit if installing a heat pump leads to the occupants also taking other energy efficiency measures such as insulation and draughtproofing.

There may also be benefits related to what is being replaced (see “Installing a new boiler”).

Noise outdoors may be a negative motive in some cases.

(g) Improve aesthetics

This is likely to have negative impact as loss of green space outdoors or the appearance of the plant may be barriers for some.

(h) Feel good about yourself

Various aspects of this motive are likely to come into play, especially as heat pumps are generally visible (both the installation process and the installed product) and still regarded as a novel technology. Any new, visible and expensive item in

the home has the potential to arouse this motive but some specifics are:

- partially fulfilling a desire for self-sufficiency (especially if the electricity is from a renewable source, such as solar);
- association with role models (as portrayed in TV programmes on ‘ecohomes’).

For other users it may simply ignite feelings of doing something for the wider good.

(i) Make my life easier

Some users will see the convenience of a fully automatic system as an added benefit. However, this motive may have negative impact, particularly in the case of an air source heat pump: although switching between heat pump and supplementary heating would be automatically controlled, the need to run and maintain two heating systems may be considered burdensome.

Opportunity

Installation of a ground source heat pump entails high capital cost, especially if a borehole is needed, and is likely to be time-consuming and disruptive. Households may also be unconvinced about service life and payback periods, simply because of lack of experience with the technology.

This combination of barriers will be sufficient to put off most householders and likely to be an insuperable obstacle to tenants unless a dedicated finance scheme is made available. In other cases, lack of space may be the critical factor.

Provision of good information may help users at least to get to the point of considering the investment by:

- making them familiar with the technology;
- pointing them to demonstration projects;
- giving a sufficiently simple explanation that potential users understand how heat pumps operate;
- setting out the marginal cost when new build, extension or system replacement is already planned.

Dwellings without access to sufficient space for trenches or boreholes will not be suitable for ground source heat pumps. Dwellings where a significant refurbishment is planned, and where the garden will be impacted already, provide an opportunity to combine installation with other activities, possibly defraying some of the installation costs.

Solar thermal water heating

Summary of change

Demand for energy to heat water would be reduced by installing solar thermal water heating to provide supplementary renewable energy.

Potential CO₂ benefit

Solar thermal water heating can provide about a third of hot water, depending on the efficiency of the system, the local climate and the water demand. It can reduce CO₂ emissions by about 325 kg per year if displacing water heating by gas but 600 kg or more if displacing solid fuel or electric heating.

MMO Analysis

Means

Owners/occupiers would install solar thermal water heating to make use of solar energy incident on the roof. Whilst the means appears relatively clear, there are some vital requirements to ensure the system operates effectively and successfully:

- access to a roof, ideally south-facing without shading (e.g. from trees or neighbouring buildings);
- no restriction on installation (e.g. by landlord or on a listed building);
- a new hot water storage vessel may be required – generally larger and with an extra heating coil;
- the vessel should be very well insulated (this is always important but especially so with solar heating as the water is only heated during daylight hours);
- optimum value will be obtained only with flexible control over the hours when a boiler is used to supplement the solar heating, independently of space heating timing (see also “Control and use of domestic hot water”);
- there may be a need for works to the roof to support the solar hot water panels;
- the householder may need to consider installing a hot-water fed shower to supplement or replace any existing electric showers in order to gain maximum benefit from the new system.

Smaller households with lower hot water usage may not see as much benefit in installing solar hot water, although they may well find they can get all their hot water from a solar system in summer and have excess available. Any excess hot water could be used with hot-fill appliances to reduce energy costs.

Considered as a whole, the means appears relatively complicated, and will require expert guidance to achieve the best results. The need for clear, non-technical and reliable information to potential users is also indicated by the facts that (a) there are various different types and qualities of system, (b) solar thermal is easily confused with photovoltaic systems, (c) users will need to manage two sources of hot water and (d) few people are likely to be considering this option (because of cost).

This information should focus on the following points.

- What each type of solar system does and which one is best suited for the various purposes they are used for (i.e. solar thermal is for providing hot water, not generating electricity).
- The requirements for effective application, as noted above.
- Planning consent is not generally required, although the details of what is permitted development should be checked.
- Where to find information regarding installation and suppliers.
- The benefits of solar thermal water heating and how to maximise them by the timing of hot water demand.

There is also an advantage in the system itself providing real-time feedback on when hot water is available.

Some avoidable risks also need to be noted in the information provided, along with clear and accessible advice on mitigating these risks.

- Scalding – the water temperature can exceed 60°C unless there is a thermostatic mixer valve on the hot water outlet from the storage vessel.²⁰
- Children and some elderly people may not remember the risks and therefore mitigating the risk of scalding is even more important where they are present.
- Legionnaires' disease: *Legionella* bacteria can multiply when water is stored close to human body temperature, which can occur – especially in spring/autumn – if neither the solar thermal system nor the boiler raises the water temperature to above 50°C. The risk is greater

²⁰ A secondary cooling system on the rooftop array would also work, and would also reduce the risk of heat damage to the system (e.g. when a house is empty and no water is being drawn off) but this is a more complex and less efficient approach and, in practice, not used.

if cold water storage is not properly covered to keep the water relatively clean.

Motive

(a) Save the planet

(b) Save the country

(c) Save my household

All apply. Motive (c) may be underpinned by seeing solar thermal water heating as contributing towards being self-sufficient in energy and therefore providing some kind of energy security.

(d) Save (or make) money

Although the capital cost is high, and payback period long, motive (d) may still be significant if producing energy (i.e. hot water) tends to be perceived as a greater financial benefit than saving energy. Installing a solar thermal hot water system could also extend the life of a boiler because the amount of work the boiler has to do is reduced, although this benefit is difficult to quantify.

There is also some direct benefit on resale or rental value of the home because the measure is generally attractive – directly as an energy-saving measure and for the wider reasons discussed here.

(e) Avoid waste

This is not a strong motivation, although some energy is saved through the use of solar hot water.

(f) Wellbeing: be healthy, comfortable, safe and productive

This motive is likely to have only marginal influence although a few points will carry some weight with some individuals, mainly related to the boiler being fired up for less of the time:

- the noise generated from a boiler is higher than that generated from the pump of solar thermal system, and may be mildly annoying in some locations;
- a boiler emits pollutants from the flue, which might affect the air quality in the immediate vicinity.

Other individuals may be more influenced (against installation) by being unconvinced about mitigation of the risks noted under Means.

(g) Improve aesthetics

This is unlikely to be a motivation, as there are no clear aesthetic benefits.

(h) Feel good about yourself

This is applicable in all the key respects because the alteration to a building is very visible and more distinctive than, say, loft insulation or a new boiler.

For example, there is likely to be a strong influence for reasons of:

- developing a technical competence;
- partially fulfilling a desire for self-sufficiency;
- promoting a positive self-image and gaining social acceptance;
- taking pride in the neighbourhood (this may play an even greater role in the future if a majority of buildings acquire solar thermal systems, but we are a long way off this at present);
- association with role models (as portrayed in TV programmes on 'ecohomes').

(i) Make my life easier

This motive may have negative impact, as the system is likely to be more complicated to use than a boiler alone, and the householder is required to manage and operate an additional system in the home.

Opportunity

The most significant issue around opportunity is likely to be the high capital cost and long payback period in comparison to many other measures, even though maintenance costs are low. Installation of solar panels is also not a DIY job: it involves multiple professions, such as plumbers, electricians and roofers. There may also need to be a significant investment of time to select the right system and get the best price; this makes easy access to trusted information a potentially critical factor.

On the positive side, a solar thermal system, being visible and (at present) unusual, can add more prestige and value to a property than loft insulation or a new boiler, for example. Therefore, part of the payback may come through sale price of the home.

Nevertheless, overcoming the opportunity issues is more likely to come from adding solar thermal installation to grant schemes or perhaps through economies of scale, i.e. implementing them in an entire street.

Because of the capital cost, installation is unlikely to be attractive to tenants in the absence of financial systems to pass on a proportion of the cost to the landlord or future tenants.

Photovoltaic power generation

Summary of change

Use of photovoltaic (PV) panels to generate electricity will reduce demand for non-renewable power.

Potential CO₂ benefit

The CO₂ benefit will vary depending on the size and type of the photovoltaic panels and their orientation. However, a typical home PV system could save around 1200 kg of CO₂ per year.

MMO Analysis

Means

Owners/occupiers would install photovoltaic panels to make use of solar energy incident on the roof. Whilst the means appears relatively clear, it has a high capital cost and there are also some vital requirements to ensure the system operates effectively and successfully:

- at high latitudes such as in the UK, it is important to site panels optimally, ensuring that the roof is south-facing without shading (e.g. from trees or neighbouring buildings);
- no restriction on installation (e.g. by landlord or on a listed building);
- there may be a need for works to the roof to support the panels;
- power is generated during daylight hours, so householders will need advice on how best to use this energy, for example setting timers on appliances to run during the daytime.

Considered as a whole, the means appears relatively complicated, and will require expert guidance to achieve the best results. The need for clear, non-technical and reliable information to potential users is also indicated by the facts that (a) there are various different types and qualities of system, (b) few people are likely to be considering this option (because of cost).

This information should focus on the following points.

- What each type of solar system does and which one is best suited for the various purposes they are used for.
- The requirements for effective application, as noted above.
- Planning consent may be required, although the details of what is permitted development should be checked.
- Where to find information regarding installation and suppliers.

- What grants are available.
- Information on how best to take advantage of solar electricity, for example having the washing machine loaded and on a timer so it runs when the energy is available.

There is also an advantage in the system itself providing real time feedback on the amount of energy being generated.

There are a number of options for PV, including large panels or roof tiles. Information on the different types and their advantages should be provided – roof tiles may be easier to get planning permission for, and may require fewer alterations to the existing roof structure.

Householders should also consider solar thermal water heating ahead of PV, as that technology provides some benefit all year round whereas PV is much less effective in winter months.

Motive

- (a) *Save the planet*
- (b) *Save the country*
- (c) *Save my household*

All apply. Motive (c) may be underpinned by seeing PV as contributing towards being self-sufficient in energy and therefore providing some kind of energy security. Relying on solar panels alone would not generate enough energy to run a home, but would provide some supplementary energy.

- (d) *Save (or make) money*

Although the capital cost is high, and payback period long, motive (d) may still be significant if producing energy tends to be perceived as a greater financial benefit than saving energy.

There is also some direct benefit on resale or rental value of the home because the measure is generally attractive – directly as an energy-saving measure and for the wider reasons discussed here.

- (e) *Avoid waste*

This is not an obvious motivation, as this behaviour is about generating rather than saving electricity.

- (f) *Wellbeing: be healthy, comfortable, safe and productive*

This is not a strong motive for this behaviour.

(g) Improve aesthetics

This may be a motivation for some, as solar panels (particularly in the form of roof tiles) may be considered attractive.

(h) Feel good about yourself

This is applicable in all the key respects because the alteration to a building is very visible and more distinctive than, say, loft insulation or a new boiler. For example, there is likely to be a strong influence for reasons of:

- developing a technical competence;
- partially fulfilling a desire for self-sufficiency;
- promoting a positive self-image and gaining social acceptance;
- taking pride in the neighbourhood (this may play an even greater role in the future if a majority of buildings acquire PV, but we are a long way off this at present);
- association with role models (as portrayed in TV programmes on 'ecohomes').

(i) Make my life easier

This motive is not relevant – the system is no more easy or difficult to use than standard mains power once it is set up.

Opportunity

The most significant issue around opportunity is likely to be the high capital cost and long payback

period in comparison to many other measures, even though maintenance costs are low. Installation of PV is also not a DIY job: it involves multiple professions, such as electricians and roofers. There may also need to be a significant investment of time to select the right system and get the best price; this makes easy access to trusted information a potentially critical factor.

On the positive side, a PV system, being visible and (at present) unusual, can add more prestige and value to a property than loft insulation or a new boiler, for example. Therefore, part of the payback may come through sale price of the home.

Situations where the home is mobile (e.g. boats or caravans) are also favourable for uptake of PV technology, as the availability of off-grid electricity may outweigh the capital cost.

Nevertheless, overcoming the cost issues is more likely to come from adding PV installation to grant schemes or through the advent of feed-in tariffs for renewable electricity, or perhaps through economies of scale, i.e. installing PV in an entire street.

Because of the capital cost, installation is unlikely to be attractive to tenants in the absence of financial systems to pass on a proportion of the cost to the landlord or future tenants.

Annex B. List of workshop participants

Tracey Bedford – University of Surrey

Rory Bergin – HTA

Ben Castle – Energy Saving Trust

Chris Clegg – University of Leeds

Andrew Cripps – AECOM

Tina Dallman – Department for Energy and
Climate Change

Bill Gething – Feilden Clegg Bradley Architects

Malcolm Gilmore – Arup

Adrian Leaman – Arup

Kevin Lomas – Loughborough University

Catrin Maby – Severn Wye Energy Agency

Brian MacNamee – Consulteco Limited

Caroline Regan – Energy Saving Trust

Noel Rice – Northern Ireland Housing Executive

Michelle Shipworth – University College London

Elizabeth Shove – Lancaster University

Rosie Smith – Communities and Local
Government

Fionn Stevenson – Oxford Institute for Sustainable
Development

Annex C. The motives

Motivational approaches traditionally split along lines of carrot and stick, and energy use in buildings is no different. The sticks include mandatory requirements – either legal (such as those in the Building Regulations) or industry-based (e.g. those imposed by professional bodies or lender/landlord organisations). Sometimes the requirement is to provide information (e.g. the predicted energy usage and/or CO₂ emissions according to some standardised model), which can then also take on a carrot role because of the positive image created by obtaining a good rating.

While these are essential elements of a strategy for reducing CO₂ emissions by changing behaviour, the focus here is on situations where users have a choice. This is particularly relevant in considering existing buildings, where there is generally a lesser degree of mandatory control.

The other main sticks are financial – some kind of tax or levy on energy use or energy-using appliances. These can alternatively be viewed as carrots – save energy, save money. This is not how they are initially constructed but it is worthwhile considering whether it would be a more effective way of presenting them. The Brussels Metro takes this approach: posters advise passengers how much money they can save by not entering or exiting after the doors start to close.

The carrots are generally more diverse and flexible than the sticks. They can be characterised as follows.

- (a) Save the planet.
 - Reduce CO₂ emissions to avoid dangerous climate change.
 - Reduce global pollution and depletion of natural resources.
- (b) Save the country.
 - Achieve security of energy supply and national self-sufficiency.
 - Avoid environmental degradation in other countries leading to wars and mass movement of people – some to the UK.
- (c) Save my household.
 - Avoid loss of land, severe weather, floods and property becoming uninsurable and losing value.
 - Maintain local security of energy supply.
- (d) Save (or make) money.
 - Save money on fuel bills.
 - Make money by selling electricity.
 - Increase property value.
 - Spend money on something else, e.g. heating or non-energy needs.

- (e) Avoid waste.
 - Reduce energy wastage.
 - Reduce wastage of other resources.
- (f) Wellbeing.
 - Be comfortable and healthy.
 - Increase productivity – in employment or domestic work.
 - Get safer appliances, building fabric or lifestyle.
 - Enhance security (or perceived security).
- (g) Improve aesthetics.
 - Improve the look (or feel) of my home or something within it.
- (h) Feel good about yourself.
 - Doing something for the wider good.
 - Taking pride in the neighbourhood, city or country.
 - Developing a technical competence.
 - Teaching the next generation.
 - Fulfilling a desire for self-sufficiency or personal control.
 - Becoming more in tune with nature.
 - Gaining social acceptance or avoiding social rejection.
 - Promoting a positive image of the person, household or organisation.
 - Association with role models.
- (i) Make my life easier.
 - Reduce the burden of an activity or task.

These motives are described in more detail below.

(a) Save the planet

For some people, it is sufficient that we need to reduce CO₂ emissions in order to avoid further dangerous climate change. Others either do not believe that climate change is a risk (globally or to them personally), do not think they can make a difference in a global context or see it as somebody else's responsibility.

Hence, it is essential to keep up research and publicity on global warming and its likely consequences – the more widely these are understood and accepted, the easier it will be to change behaviour. A risk is that thinking flips to the opposite extreme: the situation is already a disaster and we are without hope so “eat, drink and be merry, for tomorrow we die”. There is a balance to be struck in the message. Similarly, in disseminating the message that technological solutions are being developed, there is a risk of sending a message that, therefore, we all just

need to wait for the scientists and engineers to sort it out.

Pollution and depletion of natural resources are also real issues but not high in everyone's concerns. Some people have a greater understanding of (and concern for) pollution than climate change; in such cases, it has been suggested that it may be more helpful to talk about "carbon pollution" than CO₂ emissions.

(b) Save the country

Logically, saving the planet does include saving the country but there is an additional element that can be a source of motivation at national level: security of energy supply. The crisis in January 2009, when Russia cut off gas supplies to Ukraine and other parts of eastern Europe, showed this quite starkly. A country that can be self-sufficient in its energy supply is a more secure country.

Another issue at national level is that environmental degradation in other countries may lead to wars and mass movement of people – both UN Convention refugees and 'environmental refugees' – some of them to the UK.²¹ The key themes here are conflict and competition: major climate change can severely curtail the resources available to groups of people, who then compete for land or other resources held by others. Realistic scenarios for the 21st century involve people movements measured in hundreds of millions, so everyone is affected.

(c) Save my household

There is some tendency to think that it would be nice for the UK to be a bit warmer and only countries that are already hot need to worry. Presenting the full facts points to a wide spectrum of risks to individuals in the UK: loss of land, severe weather, floods, and property becoming uninsurable and losing value.

Combining this with the issue of energy security, there may increasingly be concern in some quarters over supply to particular premises (as distinct from the country as a whole). Power shortages or wind damage to power lines, for example, may motivate investment in personal or local power generation.

(d) Save (or make) money

Reducing CO₂ emissions generally involves reducing energy use and, therefore, saving money (or making money by selling locally generated electricity to the grid). Some energy-efficiency interventions will also enhance the value of the home at point of sale or letting. Some people do not easily connect with the motive of saving money

but are motivated by having money to spend on other things, so the way information is phrased can be critical.

While money is an important (and widely used) motivator, net financial benefit is not perfectly correlated with net environmental benefit and so some care needs to be taken in any blanket financial incentives. For example, the financial incentives may appear small to some users (or to all users, but with potentially large benefit at national level), or actions with substantial CO₂ benefit may have high initial costs and long payback periods.

Another risk is that those who invest in reducing energy use do not see their energy bills reduced because suppliers increase unit costs to compensate for reduced volume of sales. There needs to be a coherence of strategy so that it is clear whether costs are being used as a carrot or a stick, and there is a fair sharing of the benefits of investment.

One approach to using the financial motive is various forms of energy labelling, which can enhance the value of buildings that get a good rating. While this is a popular and generally positive approach, the advertised energy efficiency is rarely achieved in practice because of some combination of incomplete modelling, failure to build as designed (through error or by intention) and failure to operate as intended. The latter is of particular relevance in this paper: there is concern that regulation and energy labelling encourages ever more complex design, which building occupants are not capable of managing in practice.²²

(e) Avoid waste

Avoiding waste is an element of the first four motives but there is also – for some households at least – an inherent dislike of waste, regardless of whether any money is saved or the prospects for long-term availability of a commodity. This motive may be particularly significant for more affluent households where saving money, as such, is less critical.

Waste avoidance may also be a barrier if old, inefficient technology is retained when there would be a net CO₂ benefit from replacing it. For example, when considering replacement of an inefficient boiler, households may feel that it still works and it is therefore a waste to replace it. This might be overcome by providing clear, convincing information about the resources saved by fitting a new boiler, and highlighting benefits in terms of reduced maintenance costs, improved rental or house price, etc. More generally, life cycle costing needs to be more widely applied.

²¹ www.unhcr.org/cgi-bin/texis/vtx/search?page=search&docid=4901e81a4&query=convention%20on%20refugees

²² Bill Bordass, Carbon Buzz launch, Nov 2008.

(f) Wellbeing: be comfortable, healthy, safe and productive

Certain energy-saving measures also make the indoor environment more comfortable and/or healthy – either directly (e.g. insulation making a home warmer, double glazing making the indoor environment quieter and more secure, or heat-recovery ventilation improving indoor air quality and reducing problems with damp, mould and mites) or indirectly by making more resources available for heating or unrelated needs such as food.

Being healthy and comfortable should also increase productivity although the relationship is not simple or direct. This applies mainly where the home is a workplace (for paid, voluntary or domestic work) but there may also be knock-on effects on work outside the home if consequences for health persist outside the home.

As with the financial incentive, becoming more comfortable or healthy does not correlate perfectly with reducing CO₂ emissions, indeed there can be a weak or even negative relationship. A particular example of this is the widespread finding of 'comfort taking', i.e. that upgrading homes may achieve only a fraction of the anticipated reduction in energy consumption because the occupants take the benefit in higher winter temperatures rather than reduced bills.

There is sometimes good reason for comfort taking (i.e. it was uncomfortably cold before the upgrade) and sometimes it is a result of inadequate heating controls (or explanation of how to use the controls) or simply a desire to have the luxury of moving around the house in a constant high temperature and light clothing ('trophy warmth'). In extreme cases, energy consumption may actually increase because heating is seen as better value for money when it keeps the home warm, more of the home can be kept warm or more time is spent in the home.

This has particularly sensitive implications for where to target building upgrades: a focus on upgrading the homes of low-income households makes sense in social terms but not necessarily in CO₂ terms. The group with the largest potential CO₂ benefit from building upgrades may be those in poorly insulated buildings with inefficient heating systems who are, nevertheless, wealthy enough to be keeping warm. The two aims of improving health/comfort and reducing CO₂ emissions are both important but they may push policy in different directions; this needs to be acknowledged and policy aims clearly set out, especially in relation to energy price rises and their effects on different income groups.

In similar vein, there may be circumstances in which safety may be the consideration that draws someone into behaviour that reduces energy use.

This can range from replacing an old boiler because of fears of carbon monoxide poisoning to turning off appliances when they are not in use to reduce the risk of electrical fires. The fear might or might not be well founded and proportionate; from an energy perspective, the issue is whether it provides the opportunity for a positive change in behaviour.

It is particularly important to consider the very young and very old, and others who for health reasons may have different environmental quality requirements, and whose environment may be controlled by carers.

(g) Improve aesthetics

Beyond the functional benefits of some energy efficiency measures, aesthetics can be a factor: whether the home or some part of it looks (or feels) attractive can make or break attempts to instigate change. For example, 'looking modern' is important to many people.

While some other motives can relate to slow or small benefits, an aesthetic improvement can be immediate and (to the householder) very important.

Together with wellbeing, aesthetic quality represents a general theme of enjoying the living environment. It can also contribute to the next motive.

(h) Feel good about yourself

A positive self image (for individuals or the household as a whole) can result from changes in behaviour that reduce energy use or CO₂ emissions and, for some people, this can be the most important motive.

This does not necessarily imply selfishness – it stems from the importance of the social context of actions, and can be altruistic and derive from a feeling of doing something for the wider good (related particularly to the "Save the planet" and "Save the country" motives). More broadly, it can relate to the individual or derive from taking pride in the neighbourhood, city or country.

The motive can be seen as a mixture of self esteem and 'kudos', alongside conforming with social norms and aspirations, for example through:

- developing a technical competence;
- teaching skills and responsibility to the next generation (where people interact children in some capacity);
- fulfilling a desire for self-sufficiency;
- becoming more in tune with nature (alongside, for example, actions such as selecting seasonal food and maximising walking);

- gaining social acceptance or avoiding social rejection (generally or within a particular social group);
- association with role models (sports stars, entertainers, intellectual leaders, even political leaders).

(i) Make my life easier

If a technology or behaviour can make someone's life easier, it has an inherent attraction. This is different from the behaviour itself being easy to undertake. So, for example, switching off a light is easy but a 'kill switch' makes it easier to turn off the lights; turning down a thermostat is easy but simple, effective heating controls make life easier by reducing the need to make constant changes all round the house.

This motive may be particularly relevant to changing habits, where offering an alternative, easier habitual behaviour may be effective.

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