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Assessment of the potential effectiveness and strategic fit of personal carbon trading

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

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1 Executive Summary

Context

The UK is committed to reducing its level of greenhouse gas emissions, with proposed targets in the Climate Change Bill of at least 26% reduction in carbon dioxide emissions by 2020 and at least 60% by 2050, against a 1990 baseline[1]. Personal carbon emissions are projected to constitute greater than 45% of the UK's total carbon dioxide emissions by 2015. This proportion is projected to grow, beyond that date, if full account is taken of international aviation emissions. In order for the UK to achieve the target reductions efficiently, it will be necessary for personal carbon emissions to be reduced as well as those from business and industry. If policy fails to deliver the low cost abatement potential that exists in the personal sector then the overall cost to the UK of achieving its Climate Change Bill targets will be higher.

Personal carbon trading

In this report an assessment is made of the potential economic efficiency of creating a downstream cap and trade scheme that covers the following sectors; domestic primary fuel, domestic electricity use, leisure use of road transport fuel and leisure aviation, as proposed by Hillman (2004). Alternative designs have been proposed, including more ambitious economy wide schemes, however considering the net benefit of introducing trading to the above sectors provides an insight into the added value of *personal carbon trading* generally. Downstream trading already covers all energy intensive industries through the EU ETS and after the introduction of the Carbon Reduction Commitment in 2010 will cover large non-energy intensive organisations too. The unique aspect of personal carbon trading schemes is that such downstream trading would be extended to individuals' energy use. Such an extension could only be justified should the use of downstream trading in the personal sectors show a net benefit.

The case for introducing a personal carbon trading scheme, rather than an alternative policy, relies on the additional cost of implementing personal carbon trading being justified by its driving a large enough additional up-take of cost-effective abatement in the UK. This report assesses the case.

Costs and benefits of introducing personal carbon trading

It is anticipated that the Climate Change Bill target levels of emissions reductions will be achieved in part through the UK funding international

[1] At the time of publication the Climate Change Bill is continuing its progress through Parliament. These details are therefore subject to the outcome of the Parliamentary process: http://www.defra.gov.uk/environment/climatechange/uk/legislation/index.htm

abatement. The targets represent the UK showing leadership by committing to a level of ‘effort’. This effort will deliver a fixed level of global emissions reductions. Most of these will be achieved domestically but some will be achieved internationally, through the purchase of international credits. Assuming that UK targets for the first 15 years are already set by the time personal carbon trading is introduced, the introduction of additional policies, such as personal carbon trading, will not alter the level of carbon emissions reductions that the UK effort is responsible for; instead they will alter the cost. Personal carbon trading would have a net benefit to the UK if it resulted in targets being achieved at a lower cost than otherwise. It may also bring additional benefits such as enhanced security of supply, air quality benefits, and stimulation of innovation.

If the average cost of the abatement delivered by personal carbon trading is lower than the international cost of abatement, then the policy will have a financial benefit. The benefit results from the decreased transfer of funds from the UK to the wider world in order to fund international abatement. Where personal carbon trading results in individuals undertaking abatement options costing more than the international price for abatement, there will be a net financial cost to the UK; the UK could have achieved the same environmental outcome more cheaply through funding abatement abroad. Annex A provides more detail.

For example, if the cost of funding international abatement was £30/tCO_2 and personal carbon trading unlocked 1 million tonnes of additional domestic abatement that cost only £20/t CO_2, then there would be a financial benefit of £10million pounds.

Personal carbon trading will show a net benefit to the UK if the financial benefit is larger than the costs of introducing and running a personal carbon trading scheme. These costs include; administration and implementation costs, enforcement costs, time costs, and the costs of any perverse outcomes.

To justify the introduction of personal carbon trading it would be necessary to show not only that it carried a net benefit, but also that it compared favourably with alternative policies. Comparison with an upstream cap and trade with revenue recycling is considered in Section 7.

In the case that a decision is taken that the UK must meet a higher proportion, or all of its target reductions in emissions from domestic abatement, then the value of the benefit from personal carbon trading changes. In this case, the benefit of personal carbon trading will be how the cost of delivering the abatement domestically is affected by its introduction. This is necessarily a comparative question, comparing how the cost of delivering a domestic abatement target with personal carbon trading would compare with alternative policies. Section 7 also considers how the cost of delivering a required level of domestic abatement with personal carbon trading would compare to the cost using an upstream trading scheme.

Strategic fit of personal carbon trading

There are barriers to the exploitation of some cost effective abatement potential in the UK. A barrier is something that inhibits a decision or behaviour that appears to be economically efficient. The overall cost to the UK of achieving its abatement targets will be higher if barriers are not addressed. Personal carbon trading will be effective to the extent that it reduces or removes barriers that are not being addressed by existing and planned policies.

The strategic fit is considered in 2013 and 2020. 2013 is considered as an earliest possible introduction date. 2020 is used to represent a later date at which point there may be greater flexibility in terms of the policies that co-exist with personal carbon trading.

Over 80 policies exist in the UK that directly or indirectly impact on the level of personal carbon emissions. Personal carbon trading will only be effective to the degree that it delivers additional abatement to these other policies. Even though some policies could be retired upon the introduction of personal carbon trading, significant interactions will remain even in the medium term, particularly with respect to; the EU ETS, the Supplier Obligation, Road Transport policy, the Renewables Obligation, Product Standards, Building regulations and policies that raise the visibility of personal carbon emissions.

Even where policies are retired or have expired at the time of the introduction of personal carbon trading, they will impact on its potential effectiveness to the extent that they have exhausted low cost abatement potential for individuals.

This paper surveys the present policy mix and assesses which cost effective abatement opportunities it is successfully delivering. It is found that the current strategy will deliver most of the low cost abatement opportunities from ‘technological’ measures. In other words, those measures that improve the efficiency of buildings, appliances and cars. A Building Research Establishment (BRE) report[2] projects that by 2015 all but a few cavity walls will have been filled and remaining loft insulation potential will consist of a few million lofts that require ‘topping up’. Building regulations will be tightened progressively in 2010 and 2013, with an aspiration of reaching a ‘zero carbon’ standard for new build by 2016. The current (2006) regulations also require new and replacement boilers to be of the most efficient ‘condensing’ technology. Any sizeable renovation project must now comply with regulations that require minimum standards of thermal efficiency. The energy efficiency of products and appliances will be improved through EU wide product standards, and improved labelling and awareness of the energy requirements of products. The Energy Saving Trust predicts that almost 100% of appliance sales will be ‘A’ rated or better by 2010, with an increasing market share for ‘A+’ and ‘A++’ going

[2] Building Research Establishment “Delivering cost effective carbon saving measures to homes” 2007

forward[3]. Incandescent bulbs are to be removed from sale in 2011. Car manufacturers will be required under an EU wide agreement to achieve an average emissions level from the cars they sell of 130g/km by 2012.

Households can reduce their emissions by improving insulation, buying more efficient boilers, appliances, and cars amongst others. As policies will deliver most of the technological abatement potential costing less than the shadow price of carbon, it appears that personal carbon trading will only be minimally effective in delivering additional uptake of technological measures. Some potential will not be delivered by the current policy mix, but it is argued that this is largely due to barriers that personal carbon trading would not address; most notably split-incentives between landlords and tenants.

The level of emissions in the UK can be represented by the following equation:

Emissions = Carbon\Energy Generated X Energy Used\Services Consumed X Energy services consumed

Carbon intensity of energy X Energy Efficiency (number smaller if more energy efficient) X Energy Services

Overall Energy Demand

The increase in the uptake of technological measures will improve energy efficiency, thereby reducing the level of emissions. However the overall level of energy demand in the UK is a product of both energy efficiency and the level of energy services that are demanded. If the level of demand for energy services increases faster than the improvements in energy efficiency, then the overall level of energy demand in the UK will increase. For a given carbon intensity of energy supply, this will result in an increase in emissions despite the improvement in energy efficiency.

The overall level of energy demand in the UK has been increasing by 0.5% per year between 1980 and 2006[4], despite improvements in energy efficiency. Though heating a given space may take less energy due to improved insulation, the UK is heating more spaces, heating them to higher temperatures and heating them for more of the year. Alternatively, while the average efficiency of vehicles sold in the UK has improved, the number of miles driven by personal vehicles has also increased.

Behaviour change can result in additional abatement not only through changes in individuals' choices of technology, but by changing the level of energy services that they demand. Personal carbon trading could potentially be justified if it were effective at encouraging individuals to demand fewer energy services. This lower demand could arise through encouraging individuals to waste fewer

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[3] "Sustainable products – improving the energy efficiency of energy using products" – Market Transformation Programme: http://www.mtprog.com/ReferenceLibrary/Sustainable_products_consultation_Chapter_3_wet.pdf

[4] DBERR, "UK Energy in brief" July 2007

energy services; such as turning off lights when leaving a room or optimising the use of home heating more carefully. Lower demand for energy services could also arise due to changes in lifestyle choices; choosing to holiday locally for instance. However as this may, in part, involve living in a colder house or driving fewer miles; some might argue that this is not a universally desirable outcome.

Potential for personal carbon trading to deliver additional cost effective abatement

Personal carbon trading would address two barriers. It would create a ‘carbon price’ and increase the awareness of personal carbon emissions through raising the visibility of personal carbon emissions.

The carbon price would encourage individuals to take into account, when making decisions, the damage done by the carbon emissions. By increasing the cost of carbon intensive activities, they would become relatively less attractive. The visibility of personal carbon emissions would be raised through ownership of a carbon account and the additional carbon transaction required for the payment for electricity, domestic fuel, road transport fuel and airline tickets. This visibility could increase awareness. Raised awareness would be expected to encourage individuals to reflect on their own level of emissions and consider ways in which they could reduce them.

How effective personal carbon trading’s impact on these two barriers will be, depends on the policy landscape into which personal carbon trading is introduced, which barriers these policies are already addressing, and where unexploited cost effective abatement potential remains.

Assessment of the benefits of the carbon price delivered by personal carbon trading

The carbon price created by personal carbon trading would be unlikely to be allowed to rise without bound, in the event `that abatement costs were more than expected. For instance, too high a price for allowances may raise fuel poverty concerns. A price that was significantly higher than the price paid for the right to pollute by business through the EU ETS would be unpopular for some, and inefficient; a price above the international market price for abatement would drive the uptake of abatement options that were more costly than the financial benefit they would deliver to the UK. Finally it would be hard to justify a carbon price that was greatly in excess of the government’s own assessment of the damage done by carbon dioxide emissions, the shadow price of carbon[5].

[5] See guidance of the shadow price of carbon:
http://www.defra.gov.uk/Environment/climatechange/research/carboncost/index.htm

To limit the price of allowances in the Carbon Reduction Commitment (CRC), a buy-only link has been proposed with the EU ETS. This limits the price of allowances in the CRC to no higher than the price of EU allowances. A similar approach could possibly be adopted for personal carbon trading. For the CRC this link is viewed as providing a safety valve while still guaranteeing an environmental outcome; the overall abatement delivered by the CRC will be in line with its cap, either through abatement it delivers domestically or through the purchase of EU allowances which are then retired. However where the abatement is delivered through the purchase of EU allowances this should not be considered as a benefit, as EU allowances could have been purchased and retired at the same cost without the introduction of the policy. Only additional abatement that is delivered in the UK should be considered as a benefit of personal carbon trading.

The setting of a cap in line with the requirements of the UK carbon budgets which will be set under the Climate Change Bill, with individuals funding international abatement should target reductions not be reached, is an attractive management tool for policy makers. This ease of management carries a benefit, but it is in the form of Government time. There would be no financial benefit to the UK to the extent that personal carbon trading stays within its cap through the use of a buy-only link with the EU ETS.

The Shadow Price of Carbon provides a good estimate for the upper bound of prices for personal carbon trading allowances. In 2013 this is estimated to be £29/tonne of carbon dioxide and in 2020 £33/ tonne. If allowances were to reach this maximum, the increase in the price of domestic energy and personal transport would be relatively small:

- 15% increase for domestic electricity and gas;
- 7% increase in the price of road transport fuel; and
- 10% increase in the price of airline tickets.

There is evidence that demand for domestic energy and road transport fuel is highly price inelastic for price changes from current price levels. Estimates suggest -0.3[6] in the long run. The carbon price itself would therefore be expected to have a limited impact on demand for energy; less than a 5% reduction.

Personal carbon trading could not be justifiable as a result of the carbon price it delivers. Other policies, carbon taxes or upstream trading, could deliver a carbon price at much lower cost. As a result the key benefit of personal carbon trading is the increase in the visibility of personal carbon emissions that it creates. The comparison between personal carbon trading and upstream trading, below, highlights this point. Both will deliver a carbon price, but only personal carbon trading will create visibility. The additional cost of personal carbon trading with respect to upstream trading must be outweighed by the

[6] "Policy options to encourage energy efficiency in the SME and public sectors", NERA. http://www.nera.com/publication.asp?p_ID=3010

additional financial benefit it delivers through this visibility unlocking additional cost-effective abatement.[7]

Assessment of the additional visibility delivered by personal carbon trading

There is apparently a large potential for behaviour change to reduce individuals' personal carbon emissions. Much of this reduction would be at low, no or negative cost; such as individuals developing the habit of always turning the light off when leaving a room. Much personal energy use is largely invisible; additional feedback about personal energy use has been shown to change behaviour and reduce demand for energy[8]. Indirect feedback provides aggregated feedback about individuals' energy use. This is estimated to produce reductions in demand for 0-10%. Direct feedback provides real time information about the level of energy use; this has been shown to produce a greater reduction in demand. An estimate of the range is 5-15%.

Personal carbon trading would raise the visibility of personal carbon emissions. It would provide indirect feedback at the time when individuals purchase or pay for their energy or flight tickets. In addition, it would provide information for individuals on their overall carbon footprint, including an indication of whether this was less or more than their allocation, and finally it would create a 'stop and think' moment during payment. Categories of visibility delivered by personal carbon trading:

1. Indirect feedback on emissions.
2. Feedback about overall level of individual's carbon emissions.
3. A 'stop and think' moment at the point of purchase.

The visibility delivered by personal carbon trading would only deliver additional abatement to the extent that it raises the visibility of personal carbon emissions beyond that delivered by other measures. The proposed introduction of smart-metering in all homes within 10 years will result in direct feedback to individuals on their domestic energy use. Better billing will also deliver improved indirect feedback. The indirect feedback delivered by personal carbon trading in the home will not be additional. Individuals will also have clear information about their overall level of carbon emissions from the use of gas and electricity. Though this will not provide a link with their emissions from personal transport, it will provide some of the feedback that personal carbon trading would deliver on the overall level of personal carbon emissions. This will significantly limit the additional visibility that would be delivered in the home by personal carbon trading.

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7 Wider social benefits, such as air quality improvements, should be included in the calculations of the cost of abatement, however energy security is valued qualitatively in cost-effectiveness analysis.

8 "The effectiveness of feedback on energy consumption". Sarah Darby. http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

The level of emissions associated with the purchase of road transport fuel or aviation tickets is not visible, and there are no current or planned policies to address this. However, regulations requiring fuel pumps and airline tickets to prominently display the carbon content of a purchase would be low cost and deliver the type of indirect feedback created by personal carbon trading.

The information about individuals' overall carbon footprint provided by personal carbon trading will not in all cases be comprehensive or representative. Any transactions where an individual 'pays as they go' will not be registered on their account. Where a home or car is in shared use between personal and business use, the proportion of the carbon paid for by the individual rather than business will be difficult to decide accurately. Finally in multi-occupancy households, joint bills will mean that transactions on an individual's account will not accurately represent their personal responsibility.

The visibility benefit will be impaired where individuals choose to engage as little as possible with the scheme. This will be an option as individuals could sell all their allocation of allowances and then just choose to 'pay as they go' for the rest of the period. This has been suggested as an option for those that find the scheme too baffling, and could be rational for those that value the benefit of avoiding the hassle involved with participating in the scheme[9]. Such disengagement may increase as initial interest in the scheme is lost.

The additional transaction with carbon allowances at the point of sale of energy or flights would create a 'stop and think' moment. This has the potential to raise awareness beyond the level which would be created by indirect feedback. There would be an optimal level of hassle for the additional transaction, which should be a consideration for the design of the payment infrastructure. Too little hassle and the prompt to stop and think would be reduced; a potential downside to the use of smart cards. On the other hand, too much hassle and there would be an increased incentive for individuals to disengage from the scheme.

Assessment of the costs of personal carbon trading

Implementing personal carbon trading would involve significant costs. It would require I.T. and banking systems, payment infrastructure, and secondary markets. If the downstream coverage of personal carbon emissions was part of a wider economy wide cap and trade scheme, such as the Domestic Tradable Quotas[10] proposal, then an auctioning system would also be required. In addition to the implementation, there would be ongoing costs for administration, verification, auditing and enforcement.

As part of the pre-feasibility study, another report, looking at the technical feasibility and costs of implementing personal carbon trading, has provided an

[9] Richard Starkey, from the Tyndall centre, made this point in his evidence to the Environmental Audit Committee 2007.
[10] For details: http://www.carbonequity.info/PDFs/Tyndalldtq.pdf

estimated range for the costs. Initial set up costs would be between £700million and £2 billion. Running costs would be between £1 and £2 billion a year. Table 1 illustrates the implementation costs per person per year for personal carbon trading, and the additional costs for personal carbon trading over and above an upstream scheme.

Table 1: Implementation costs per person per year[11]

	Lower Bound	Central estimate	Upper bound
Personal carbon trading	£21.68	£33.25	£44.81
Additional costs for personal carbon trading above an upstream scheme	£20.50	£32.07	£43.63

The time burden placed on individuals through the introduction of personal carbon trading must also be valued (see Table 2).

Table 2: Time burden costs per person per year

Lower bound	Central estimate	Upper bound
£10	£20	£30

A scheme that covered all adults in the UK could cover about 50 million people. A few hours per person creates a large overall figure for the time burden and if this is valued in line with the Department for Transport guideline figure for the value of lost leisure time, then the total cost of the time burden can be roughly estimated to be £1billion per year, or £20 per person per year. A sensitivity range is considered here of plus or minus fifty percent on this figure.

Table 3: Total additional costs from personal carbon trading over an upstream scheme per person per year

Lower bound	Central estimate	Upper bound
£30.50	£52.07	£73.63

Where personal carbon trading creates unintended consequences these will add a further cost to the scheme. For example the scheme would provide an incentive for individuals to take an indirect flight to Australia, via France rather than a direct flight. Although this would reduce the emissions within the UK and within the personal carbon trading scheme, it would create an increase in global emissions due to the indirect route being less fuel efficient. If individuals substitute away from energy covered within the scheme to other goods and services that embody energy, then the savings estimated by the scheme will be overstated. For example spending a greater proportion of their income on air-freighted vegetables. However these unintended consequences would also largely be present under alternative policies such as a UK carbon tax or upstream trading.

[11] Set up costs have been amortized over ten years.

Comparison of upstream cap and trade with revenue recycling and personal carbon trading

An upstream cap and trade scheme with revenue recycling would be experienced as a variable carbon price at the level of the individual. Personal carbon trading would similarly be experienced as a variable carbon price *but in addition* it would raise the visibility of personal carbon emissions. The additional cost of personal carbon trading over and above that of introducing an upstream scheme should be weighed against the additional benefit; the additional abatement it delivers due to the visibility that it creates.

The principle that visibility can be worth the extra cost is well established. The EU ETS is a downstream trading scheme as the final end users of primary fuel are required to trade. The Carbon Reduction Commitment is also a downstream trading scheme and has been largely justified on the basis that it will increase the visibility of companies' energy use at board level. However the challenge for personal carbon trading is to show that this argument still holds when the agents covered by the scheme are responsible for approximately 4.5 tonnes of carbon dioxide each, instead of hundreds of thousands of tonnes.

Both upstream trading and personal carbon trading would require secondary markets for allowances. Auctioning of allowances would be required for an upstream scheme, and for personal carbon trading if it is part of an economy wide scheme. Upstream trading would not create any additional time burden on individuals and the costs of managing a database of a few hundred participants would be negligible compared to administrating 50 million participants. There would be no costs associated with additional banking and payment infrastructure. Auditing and verification costs would also be smaller. The breakdown of costs for implementing personal carbon trading provided by the technical feasibility and costs report can therefore be used to estimate the additional costs for personal carbon trading compared to those for introducing upstream trading.

The cap on emissions implemented through personal carbon trading would influence individuals behaviour through the creation of a carbon price and increasing the visibility of personal carbon emissions. Where the combined impact of these is insufficient to drive enough abatement, without the price of allowances reaching a level that is considered 'unacceptable', the environmental outcome would be delivered through the purchase and retirement of international allowances. An upstream trading scheme would be equally able to influence behaviour through a carbon price, and to have a buy only link with an international trading scheme. When comparing the relative merits of personal carbon trading and upstream trading, the only additional benefit from personal carbon trading is the additional abatement delivered by the enhanced visibility alone. The reduction in a cap on personal carbon emissions cannot be used to estimate this benefit as this would include abatement delivered by the carbon price and through any buy only link with international schemes.

Evidence for the effectiveness of indirect feedback suggests a range of reduction in personal emissions of 0-10% - although these figures have been drawn from research on metering and energy displays rather than trials of personal carbon trading[12]. However, as discussed above, much of the visibility created by personal carbon trading would not be additional, notably in the domestic sector. Therefore it is reasonable to consider a smaller range of benefit of 0-5%. Though a 10% reduction would still not be sufficient to balance the cost-benefit assessment more favourably. It should be noted that there is no applicable evidence available from trialling or actual implementation of personal carbon trading as to the additional behavioural change the visibility might deliver. This range for the benefits is therefore a key sensitivity in the cost benefit analysis.

Central projections for UK emissions suggest that personal carbon emissions will be 237 million tonnes of carbon dioxide in 2013 and 223 million tonnes in 2020[13]. The range of potential savings of 0-5% can be used to provide an estimate of the potential benefit of these savings valuing them at the shadow price of carbon[14]; £0 - £343million in 2013 and £0 to £368million in 2020.

Table 4: Estimates of additional annual benefits delivered by personal carbon trading per participant in 2013

	Reduction in personal emissions	**lower bound**	**central**	**upper bound**
Benefit per participant	0-5%	£0	£3.45	£6.90
	0-10%	£0	£6.90	£13.80

The upper bounds indicate the maximum additional costs per participant that could be supported for there to be a net benefit to the decision to implement a personal carbon trading scheme as opposed to an upstream scheme.

Comparing the central estimate for the additional costs of personal carbon trading per person per year (£52.07) with the central estimate of the additional benefits (£3.45), it is shown that the costs are more than 15 times larger than the benefits. Even in the most optimistic scenario, where the costs are at the lower bound per participant per year (£30.50), and the additional behaviour change is at the upper bound (£6.90), the costs are four and a half times the benefit. As a result it seems unlikely that the additional cost is justified by the additional benefit. The cost per additional tonne of carbon dioxide abatement delivered by personal carbon trading's visibility, in the central case, would be approximately £500/tCO_2.

[12] 'The effectiveness of feedback on energy consumption: A review for Defra of the literature on metering, billing and direct displays', Sarah Darby, Environmental Change Institute, University of Oxford, 2006.
http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf
[13] This projection includes UK leisure aviation emissions from international departures and arrivals.
[14] It should be noted that this assumes zero net resource costs for the additional abatement.

These findings are consistent with analysis of the level of coverage that should be adopted for the CRC. For this policy it was decided to set a minimum level of energy use per participant, as through inclusion of businesses that were lower energy users, the absolute coverage only increased slightly while administration and transaction costs increased significantly. The increases in costs were such that the policy would not show a net benefit if implemented to cover small energy users. The conclusion commented:

"If all half-hourly metered sites were covered by the scheme without any exemptions for relatively small energy users, the administrative and transaction costs would be significant and would outweigh the energy-savings delivered by the scheme under most plausible scenarios."[15]

Conclusion

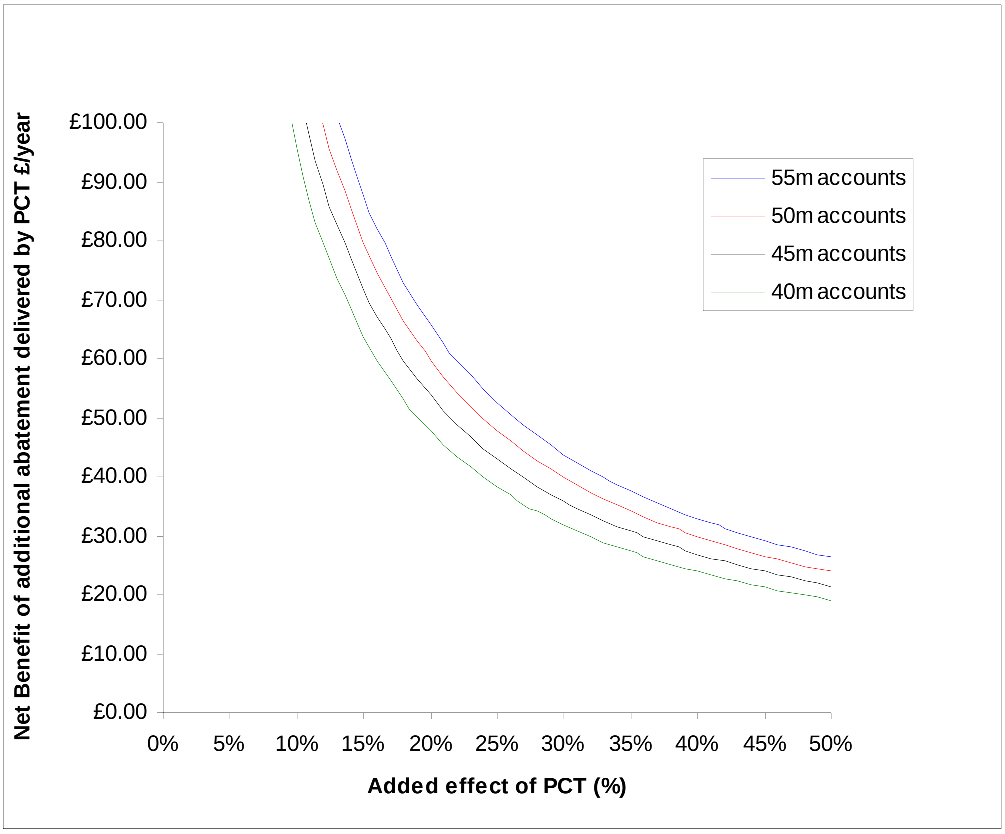
In conclusion, government policy should look to raise visibility of personal carbon emissions where it can be done cost-effectively. Increased visibility would be expected to translate into raised awareness and as a result behavioural change. However, the additional visibility delivered by personal carbon trading would be limited and as it would come at a high cost, it would need to deliver very considerable savings to be justified. This suggests that other measures to increase the visibility of personal carbon emissions and influence carbon saving behaviours should be explored.

Figure 1 illustrates the 'cost-effective space' for personal carbon trading, assuming the central costs estimate from the technical and feasibility report. The different lines are to represent sensitivities over the number of participants. Any co-ordinate of behavioural change and net benefit of the additional abatement from personal carbon trading's visibility locates a point on the graph. The points that are above the curved lines represent combinations which are cost-effective. For example, with 50 million participants, a £30 valuation of the abatement, combined with anything greater than a 40% reduction in personal carbon emissions due to the additional visibility would be cost-effective[16].

[15] "Options for the implementation of a New Mandatory UK Emissions Trading Scheme' NERA, 2006. http://www.defra.gov.uk/environment/climatechange/uk/business/crc/pdf/nera-enviros-report-060428.pdf

[16] Acknowledgement: Joshua Thumim from the Centre for Sustainable Energy suggested this method of presenting the cost benefit framework.

Figure 1: Cost-effective potential for personal carbon trading, based on central costs



There would need to be very significant revisions of the central figures used in this cost-benefit analysis for personal carbon trading to show a net benefit. Should the valuation of carbon savings be revised up sharply, combined with evidence of larger behavioural changes due to the visibility delivered by personal carbon trading, and a method of implementing personal carbon trading at significantly lower cost be found, then there may be a case for re-considering the conclusions of this report.

2 Introduction

Purpose

The UK is committed to reducing its greenhouse gas emissions and the Climate Change Bill[17] proposes a target of a reduction in carbon dioxide emissions of at least 60% by 2050 (against a 1990 baseline). Individuals are responsible for around 40% of the UK's carbon dioxide emissions (largely from heating homes and water, and leisure travel), and in order to meet our longer-term emissions targets, emissions from individuals must be reduced as well as those from business and industry.

One potential measure is personal carbon trading. This is an emissions trading scheme where equal rights to emit are allocated to individuals in the economy as emission allowances (or 'carbon credits'), which must be surrendered when purchasing goods or services that cause emissions (e.g. paying their gas bill, or refuelling their car). Anyone with surplus carbon credits could sell these to individuals who require extra (where it is cheaper to buy extra, than to reduce their emissions).

In 2006, Defra commissioned the Centre for Sustainable Energy to assess the ideas and issues involved in the concept of individual carbon trading, and a report was produced: "A rough guide to Individual Carbon Trading"[18]. The Government has since conducted a pre-feasibility study to explore key high-level issues highlighted by the CSE report: effectiveness and strategic fit; equity and distributional impacts; public acceptability; and technical feasibility and cost.

There are different types of personal carbon trading that vary depending on the emissions covered, who participates and how it might be implemented. For the purposes of this study, a Domestic Tradable Quota model has been assumed:

- A mandatory scheme involving individuals and organisations, where 40% of carbon credits are allocated free to each adult, and the remaining 60% are auctioned – traders and large organisations would make up the majority of buyers.
- 'Credits' would be surrendered to cover the carbon content of electricity and gas use in the home and for personal transport fuel purchases, with airlines covered and treated just as other fuel consumers.
- All individuals and organisations would have access to the market to trade their carbon credits.
- A 'pay as you go' option would allow individuals to pay the price of the carbon credits at the point of purchase, leaving the vendor to buy and surrender sufficient allowances for that sale.

[17] At the time of publication the Climate Change Bill is continuing its progress through Parliament. These details are therefore subject to the outcome of the Parliamentary process: http://www.defra.gov.uk/environment/climatechange/uk/legislation/index.htm
[18] http://www.defra.gov.uk/Environment/climatechange/uk/individual/pca/pdf/pca-scopingstudy.pdf

A start date range of 2013 – 2020 has been assumed, with 2013 representing the earliest possible introduction date.

This paper provides an initial assessment of the proportionality, efficiency and effectiveness of personal carbon trading compared to or combined with existing policies and other ways of achieving the same emissions reductions. This study is not designed to assess all economic or strategic policy questions that are raised by personal carbon trading, but it is intended to identify any that may make further research into personal carbon trading hard to justify, as well as those that may require further consideration should additional research be carried out.

This paper provides an economic analysis of the potential effectiveness of personal carbon trading. **The case for introducing personal carbon trading relies on it driving a large enough additional up-take of cost-effective abatement measures that would have not been delivered by alternative policies.** This case is assessed by:

- Outlining the cost benefit framework for performing an economic assessment of personal carbon trading [19];
- Surveying the policy landscape within which personal carbon trading would be placed, indicating where there is potential for new policies to deliver additional low cost abatement;
- Assessing the additional abatement and any other benefits that could be delivered, with consideration given to some underlying economic challenges to the effectiveness of personal carbon trading;
- Assessing the costs associated with implementation;
- Comparing personal carbon trading to an alternative policy that could be used to constrain personal carbon emissions (upstream trading with revenue recycling).

What is personal carbon trading?

Personal carbon trading is an emissions trading scheme where some or all of the rights to emit are allocated to individuals in the economy. Individuals are allocated allowances for a quantity of emissions which they either surrender

19 In this report, an assessment is made of the economic efficiency of creating a downstream cap and trade scheme that covers the following sectors; domestic primary fuel, domestic electricity use, leisure use of road transport fuel and leisure aviation, as proposed by Hillman (2004). Alternative designs have been proposed, including more ambitious economy wide schemes, however considering the net benefit of introducing trading to the above sectors provides an insight into the added value of personal carbon trading generally.

when undertaking activities that cause emissions, or sell on the market. For those who do not have sufficient allowances to cover their emissions, they have a choice between reducing their emissions and buying extra allowances.

By setting an allowance budget each year, the government can control the total level of emissions, while allowing the market for allowances to distribute the rights to emit to those who value them most. Those who produce fewer emissions and have surplus allowances to sell are rewarded with the money they receive from the sale. There are different 'flavours' of personal carbon trading, but this paper will provide an assessment of the economic efficiency of a scheme that covers domestic primary fuel use[20], domestic electricity, personal vehicle use and leisure aviation[21].

The Government may wish to be flexible about the number of allowances that are available in the scheme, increasing the number available should the price of allowances reach a level that is politically and socially unacceptable. This can be done by either issuing unlimited additional allowances and selling unlimited numbers of them to those prepared to pay a given 'ceiling' price. An alternative mechanism, which it has been proposed for the Carbon Reduction Commitment (CRC), is to allow participants to meet their obligations through the purchase and retirement of EU Emissions Trading Scheme allowances (EU ETS). This is a one way link as participants in the EU ETS cannot buy CRC allowances to meet their obligations. This would ensure that the price of the allowances in the CRC is always at or below the price of allowances in the EU ETS.

The option of issuing additional allowances has the advantage of raising revenue that could be used to fund energy efficiency measures, however it will not guarantee an environmental outcome in terms of the global level of emissions. The second option does guarantee the environmental outcome, but does so by participants in the scheme buying and retiring EU allowances. This way of delivering global emissions reductions existed before and could have been achieved without the cost of implementing a policy. To the extent that personal carbon trading would deliver abatement through such a link with the EU ETS there is no financial benefit to the UK.

The costs and benefits of personal carbon trading

The economic assessment of the potential effectiveness of personal carbon trading is founded in the comparison of the costs and benefits of introducing it. The benefit of introducing personal carbon trading will depend on the level of additional domestic abatement it delivers, and how this additional abatement is valued. The question of how effective personal carbon trading could be at

[20] Primary fuel refers to a fossil fuel such as gas, oil, or coal.

[21] Introducing trading at the individual level to cover these sectors is essentially what makes any design for a trading scheme 'personal'. If trading cannot be introduced cost effectively downstream to these sectors then the element that differentiates personal carbon trading from other types of trading schemes will have been shown to be inefficient. Whatever other design features a particular type of personal carbon trading scheme has, if it cannot deliver cost effective abatement in these sectors, there will be no case for its introduction.

unlocking additional abatement is considered first. Section 4 analyses the policy landscape into which it would be introduced, revealing where there is potential to add value. In Section 5 the potential effectiveness of personal carbon trading is analysed, given this policy context.

Personal carbon trading would address two barriers to the exploitation of cost effective abatement; creating a carbon price, and raising awareness of personal carbon emissions by increasing their visibility. How effective personal carbon trading would be at delivering additional abatement depends on the extent to which it would address these barriers beyond existing policies, and how much abatement any reduction in these barriers is likely to release.

How to value the benefit of additional domestic abatement delivered by personal carbon trading depends in part on the decisions that are taken on supplementarity[22] in the context of the Climate Change Bill. The Government's position so far has been that they would not wish to limit the flexibility of the EU ETS by requiring a certain proportion of abatement in the traded sectors to occur in the UK.

Under this scenario, personal carbon trading may deliver a financial benefit. Given the UK's commitment to achieve target reductions in carbon emissions, the benefit to the UK of the additional domestic abatement delivered by personal carbon trading is how much it lowers the cost to the UK of achieving these targets (see Annex A). There is a saving; additional abatement allows the UK to import less abatement through international mechanisms. There is also a cost; the resources required to deliver the additional domestic abatement. Where the cost of the additional abatement is lower than the cost of international abatement, the overall cost to the UK of achieving its targets is reduced. Assuming that the average cost of abatement delivered by a new policy is below the cost of international abatement, then there will be a financial benefit from the policy.[23]

For Example:

The UK is achieving its Climate Change Bill target partly through domestic abatement and partly through international abatement. Personal carbon trading is introduced and delivers an additional 1 million tonnes (CO_2) of domestic abatement. The cost of this abatement is £20/t CO_2. This cost reflects the resources used to deliver the abatement such as materials, and installation costs and also includes a quantification of wider social benefits such as air quality impacts. The UK could have achieved the same environmental outcome, by buying international credits, which were trading at £30/t CO_2. The additional 1 million tonnes of abatement reduces the need to buy international credits to reach the Climate Change Bill target; there is a saving of £30 million. There is a

[22] The proportion of the reductions in carbon emissions that can be met through the purchase of international credits compared to domestic abatement.
[23] Wider social benefits should be included in the calculations of the cost of abatement, so that the financial benefit referred to here is net of wider social benefits, such as air quality. However some social benefits are not quantified, in this case the financial benefit may understate the benefit from personal carbon trading.

cost of £20 million, reflecting the actual resources used to deliver the abatement. The financial benefit to the UK is therefore £10 million.

It is possible that a future government may decide that the targets must be met 100% domestically, or at least a greater percentage than was being delivered at the time. It can be argued that the UK would be showing leadership in the climate change debate by committing to an ambitious level of effort, however there are those that argue that there would be a benefit from the UK going further and showing leadership by delivering a 'demonstration project'; showing that it is possible for a developed country to de-carbonise their economy without undue cost. If this approach were to be taken, then personal carbon trading should be assessed by comparing the impact on the overall cost of achieving the target with personal carbon trading, to the cost using other policies. This is an unlikely scenario, but a complete treatment of the costs and benefits of personal carbon trading should consider it (see Annex B).

Section 6 considers the costs of introducing a personal carbon trading scheme. These costs come in three categories; set up and administration of the scheme, the time burden on individuals from engaging with the scheme and perverse effects created by the scheme. In order to deliver a net benefit to the UK, the additional abatement that personal carbon trading delivers must result in a sufficient financial benefit to more than outweigh the additional costs of introducing the scheme.

Relative benefit of personal carbon trading compared to upstream trading with revenue recycling

When considering whether to introduce personal carbon trading, the comparison is not just between personal carbon trading and nothing, but between personal carbon trading and other policy options. The Tyndall centre has noted that the correct comparison can be argued to be: "Between DTQs *[a term for economy wide* personal carbon trading*]* and other ways of equitably reducing greenhouse gas emissions"[24]. Personal carbon trading is not the only policy option. For instance, a carbon tax or an upstream trading scheme could also be introduced to constrain personal carbon emissions. Section 7 in this paper chooses to compare personal carbon trading to an upstream trading scheme with revenue recycling.

Upstream trading is experienced at the individual level as a carbon price (further details on page 58). This is the mechanism through which the creation of an upstream cap will influence decisions at the micro-level of individual decisions about whether or not to reduce emissions. Personal carbon trading will also create a carbon price, but in addition will raise the visibility of personal carbon emissions. This provides an additional channel for personal carbon trading to be effective; through raising awareness which could drive behaviour change.

[24] "Domestic Tradable Quotas: A policy instrument for reducing greenhouse gas emissions from energy use" December 2005, p34.
http://www.tyndall.ac.uk/research/theme2/final_reports/t3_22.pdf

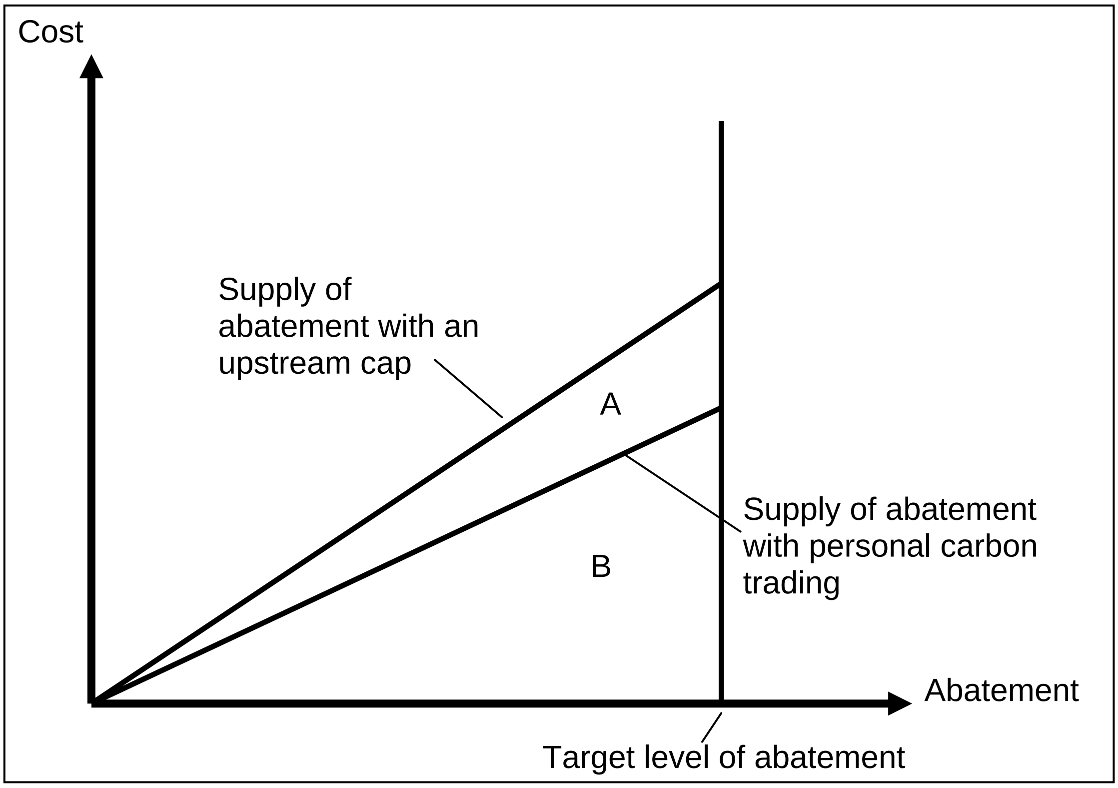
Greater awareness could encourage individuals to reflect on their energy use and emissions, and take responsibility for undertaking cost-effective abatement opportunities. This is likely to reduce the cost of a given level of emissions reductions being achieved in the UK.

This can be shown graphically for the case of a hard cap, see figure 1 below. (The benefit will differ depending on whether there is a hard or soft cap[25] in the trading systems, and the comparison between upstream and downstream trading in both of these scenarios is made in section 7.)

Figure 2 illustrates that personal carbon trading will deliver the target more efficiently due to the impact of the visibility which releases additional abatement, which it is assumed costs less than the marginal abatement that was required to meet the cap in the upstream scheme. The result is a lower overall expenditure to reach the target; for the upstream trading scheme the cost would be ‘A’ and ‘B’, but for personal carbon trading it would only cost ‘B’. The additional visibility delivered by personal carbon trading would create a reduction in cost of ‘A’. Against this reduction in cost must be set the additional costs of implementing personal carbon trading, over and above the costs of implementing an upstream trading scheme. If the cost of implementing personal carbon trading, over and above implementing an upstream scheme, is less than ‘A’, then there will be a net benefit to personal carbon trading.

[25] A hard cap is one where the number of allowances (and so CO_2 emissions) is fixed no matter what - emissions in the sectors covered by the scheme will not be able to exceed the level of the initial cap. A soft cap has a buy out/ safety valve which means that under certain circumstances extra allowances could be issued and so the emissions could exceed the initial cap - as described in ‘what is personal carbon trading?’ (pages 2-3 of this report).

Figure 2. Effect on cost of abatement for UK to meet its Climate Change Bill target using personal carbon trading rather than an upstream trading scheme



3 Strategic fit of Personal Carbon Trading

This section assesses the current policy strategy for reducing personal carbon emissions. A qualitative assessment is made of where there is unexploited cost effective abatement potential in the personal sectors, and which barriers would need to be addressed to deliver this additional abatement. It has been suggested that 2013 is the earliest date that it would be feasible to introduce personal carbon trading given the logistics of establishing a scheme. 2020 is further away in time, far enough forward to allow greater flexibility in terms of the policy landscape and which policies would co-exist with personal carbon trading. This motivates an assessment of the policy landscape up to 2020.

The assessment of the policy landscape involves:

- A review of policies that directly or indirectly impact on the level of personal carbon emissions,
- A strategic overview of the barriers to abatement opportunities are being addressed and which low cost abatement opportunities are not being delivered,
- Emissions projections for personal carbon emissions.

UK policies that impact on personal carbon emissions

For the purposes of this paper, personal carbon emissions are defined as being the CO_2 emissions associated with an individual:

- Using primary energy in the home or for transport.
- Using electricity.
- Purchasing airline tickets for leisure purposes.

This definition includes the indirect emissions associated with individuals' domestic electricity use and decisions to take leisure flights, and domestic electricity use but other than this, the definition does not include embodied energy in the consumption of goods and services. For example, neither the energy used to manufacture and transport goods nor the emissions associated with public transport (other than aviation) are included.

Channels through which policy can impact personal carbon emissions:

- Fossil fuel mix
- Energy efficiency of house
- Standards of appliances/products
- Transport
- Behaviour

There are several channels through which policy can impact on the level of personal carbon emissions. The emissions associated with a unit of electricity differ depending on the fuel used and the efficiency of its generation, so policies that drive the UK's electricity generation to lower carbon technologies will reduce emissions. Similarly, policies that encourage individuals to burn lower carbon fuels in the home reduce the emissions associated with a given amount of energy use. In addition the fossil fuel mix for transport can be changed by, for example, policy on bio-fuels. Policies can impact on the energy efficiency of the home to deliver a given level of energy services (like heat or light) while using less electricity or fuel as well as affecting the energy efficiency of appliances, products and travel (e.g. improving the efficiency of vehicles). In addition, individuals demand for energy services can be reduced by increasing awareness of energy use and the emissions and costs associated with it. The increased awareness may encourage people to change their behaviour or take into account the cost of energy used in purchasing decisions.

Table 5: Existing and agreed future policies that impact personal carbon emissions[26]

Fossil Fuel Mix	
Upstream generation	Renewables Obligation EU ETS Support for Combined Heat and Power
Downstream generation	Low carbon buildings programme Reconnect (NI) Scottish householder and Renewables Initiative Reduced VAT on micro-generation Income from selling ROCs is income tax free Distributed generation policy Environment and renewable energy fund (NI) 'Merton' rules
Transport Fuel	Renewables transport fuel obligation Fuel duty incentives for bio-fuels Fuel Quality Directive
Energy Efficiency of Houses	
New build	Building regulations Code for sustainable Homes Zero stamp duty on zero carbon homes
Existing Housing Stock	Warm Front (E); Warm Deal (S); Warm Homes (NI) Home Energy Efficiency Scheme plus (W) Decent Homes Carbon Emissions Reduction Target (CERT) Supplier Obligation Customer Levy Green Landlord Scheme Landlord Energy Saving Allowance Reduced VAT on energy saving materials Green Homes service
Behaviour	Energy performance certificates Energy Saving Trust Climate Change communications initiative Certification for micro-generation Carbon Calculator Real time electricity displays and smart-metering

[26] (This list is based on existing policies plus those policies already announced, such as the Supplier Obligation, that we supposed to exist between now and 2020. It is possible that further policies may be introduced meantime).

	Better billing Winter fuel payment 5% VAT on domestic fuel and electricity
Appliances /Products	
Standards	EU directive: Eco-design of energy using products Phase out of incandescent light-bulbs Minimum product standards
Behaviour (choice and level of demand for energy services)	EU energy labelling Energy Saving trust 'recommended' labelling Carbon calculator
Transport	
Personal transport Efficiency	EU voluntary agreements with car manufacturers Low carbon innovation platform
Transport behaviour (Vehicle purchase)	Vehicle efficiency labels Car advertising must carry emissions information Act on CO_2 campaign Graduated vehicle excise duty Climate change communication initiative Company car tax differentials
Transport behaviour (Use & mode)	Eco-driving included in the driving test DfT information campaigns Air passenger duty Transport 10 year plan Fuel duty Zero VAT on public transport Bus service operator's grant Transport Innovation Fund Cycle to work scheme Congestion Charging

Timelines for significant policies affecting personal carbon emissions

Figure 3 shows the timeline for the main policies affecting personal carbon emissions up to 2020. It should be noted that before policies come to an end, such as warm front, the Government may announce successor policies.

Policies are often necessarily long lived, in order to provide correct signals to consumers and industry. Figure 3 illustrates how, as a result, any new policy would be required to share the policy space in the medium term. Air quality policies have not been included in this assessment, but these can have a major impact too. For example, air quality legislation significantly affects coal use for generation and for domestic heating, as well as CO_2 from transport. It should also be noted that this study assesses central government policies and does not include local authority policies and programmes, especially for transport, which directly impact on peoples' carbon dioxide emissions.

Figure 3: Timelines for significant policies affecting personal carbon emissions

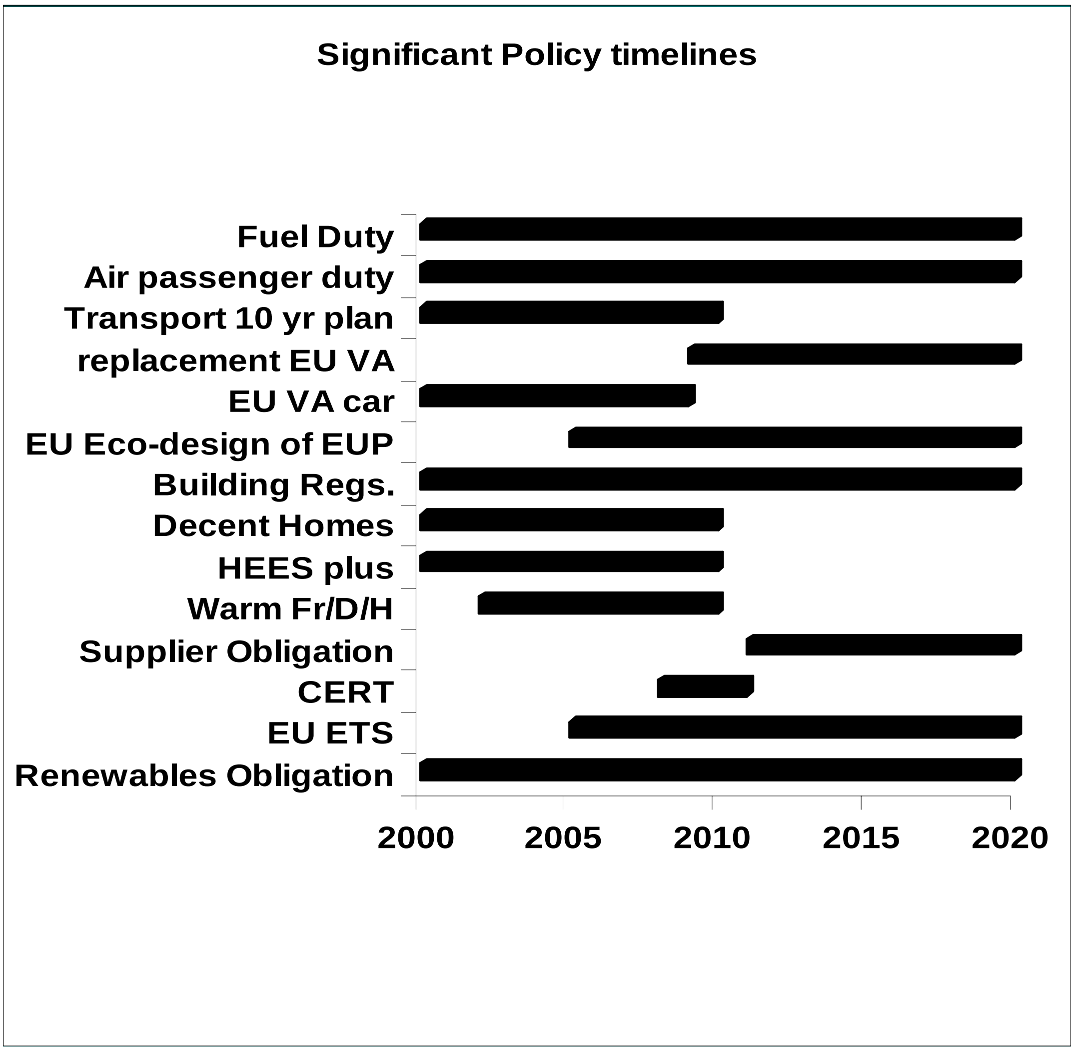


Table 6 lists policies that impact on personal carbon emissions and have had their emission reductions quantified. Other policies may deliver additional carbon savings thereby contributing to overall CO_2 reductions themselves, whilst others are "supporting policies" designed to maximize the effectiveness of other policies.

Table 6: Quantified emission reductions for policies that impact on personal carbon emissions

Policy Name	**2010 (Mt CO_2/year)**	**2020 (Mt CO_2/year)**
EU ETS Phase II	11 – 29.3	11 – 29.3
Renewables Obligation	-	9.2
Revision to Renewables Obligation, (additional)	0.7	2.9
CERT	4.0	4.0
Supplier Obligation	0	12.8
Building Regs 2005 (E&W), 2007 (Scotland), 2006 (NI)	5.5	12.1
Future Building Regs.(E&W)	0	4.4
Warm Front/ Deal/ Homes/ HEES plus (UK	1.5	1.5

Fuel poverty programmes)		
EU directive Eco-Design of Energy Using Products, and standards for lights.	0.7	3.3
Fuel Duty Escalator	7.0	7.0
Transport 10 year plan	2.9	2.9
Renewable Fuel Transport Obligation	4.4	5.9
EU voluntary agreement with car manufacturers, graduated VED and company car tax differentials	8.4	13.2
Successor to EU voluntary agreement with car manufacturers	0.4	7.3
Domestic aviation in EU ETS	0	1.1
Better Billing, Real Time displays and smart-metering	0.4	0.7
EU Energy performance of buildings directive. (Home performance certificates)	0	1.5
Energy efficient products	1.5	1.5
Product Policy (additional)	0.7	3.3
TOTAL	49.1 – 67.1	105.6 - 123.6

Figures are from: “Updated energy and carbon projections, energy white paper 2007”(BERR), and “Synthesis of climate change policy appraisals 2007”(Defra). Figures converted from carbon to carbon dioxide.

Strategic Overview of the Policy Landscape

The preceding sections list policies that impact on personal carbon emissions. This section considers how they fit together. There are significant barriers which prevent the take up of lower carbon technology, or the adoption of lower carbon behaviours. The policy landscape can be evaluated in relation to how well it addresses the barriers.

A barrier is something that inhibits a decision or behaviour that appears to be economically efficient. This means that energy efficiency measures that are apparently cost-effective may still not be taken up due to one of these barriers. **The overall cost of the UK achieving its abatement targets will be higher if barriers are not effectively addressed**. Table 2 lists common barriers that prevent the take up of energy efficient behaviours or technology, alongside the policies that, at least partly, address these barriers. A traffic light system (red, amber, green) is used to indicate how effectively the barrier has been addressed.

For barriers that are so called “market failures” there is justification for government intervention. A market failure, in broad terms, is an imperfection that prevents an economy from achieving an efficient distribution of resources through the action of markets. Examples of imperfections include poor information, and the lack of markets to exist for some goods and services. This tends to arise where no property rights have been established for the goods and services.

Other barriers are not market failures, but instead reflect hidden costs that were not included in the analysis of the cost effectiveness of the measures. Behavioural changes to reduce emissions may carry hidden costs, for example in terms of the hassle factor of remembering to switch appliances off, taking the day off to have insulation installed or adjusting the heating controls when going away. This hidden cost cannot be addressed directly by policy; however innovation provides a route through which the hidden cost can be minimised. Technological innovation that makes it easier to turn off all the lights in a house or optimize the heating provides an additional justification for government support for innovation.

Table 7 lists barriers and the policies that can be considered, at least partially, to address them. The third column is a judgement as to how successfully the policies have removed the barrier. Green indicates that the barrier is not preventing the uptake of cost-effective abatement opportunities, whereas red suggests that the barrier is still acting.

Table 7: Barriers to adoption of 'cost effective' abatement

Barrier	**Policies to address**	**Successfully addressed?**
Financial		
Up front costs of installation/ purchase.	**For Housing:** Low carbon Buildings programme Reduced VAT on energy efficient materials Reduced VAT on micro-generation Reconnect (NI) Warm Front/Deal/Homes HEES plus Decent Homes EEC/CERT/SO subsidies Zero stamp duty on zero carbon homes **For Transport:** Zero VAT on public transport Cycle to work scheme	**Amber**
Access to capital/ high interest rates	Possibly Supplier Obligation may result in suppliers offering low interest loans.	**Red**
Hidden Costs		
Search costs for reputable suppliers	EST website and centres Certification scheme for micro-generation Trade bodies Green Homes service	**Green**
Disruption of having measures installed		**Red**
Hidden costs of behavioural measures		**Red**
Co-ordination costs when measures requires co-operation of several agents.		**Red**
Psychological/Sociological		
Lack of information/awareness	Energy performance certificates Code for sustainable homes Car adverts carry emissions information Real time electricity displays EU energy labelling Energy Saving trust labelling Carbon calculator Energy Saving Trust Vehicle efficiency labels DfT information campaigns	**Amber**

Inertia/Cultural shift	Eco-driving included in driving test Climate change communication initiative Act on CO_2	**Amber**
Poorly aligned incentives		
Landlord-Tenant split incentives	Green Landlord scheme Landlord energy saving allowance	**Red**
Building supply chain	Building regulations Planning Code for sustainable homes Energy performance certificates Zero stamp duty on zero carbon homes	**Green**
Carbon emissions are economic bads (externalities) which is not reflected in price signals to individuals. No carbon price.	**For Housing:** EU ETS Renewables Obligation Possibly Supplier Obligation may be cap and trade **For Transport:** Renewable Transport Fuel Obligation Duty incentives for Bio-fuels Air passenger duty Fuel Duty Congestion charges Transport Innovation fund Low carbon innovation platform Graduated vehicle excise duty EU VA with car manufacturers	**Amber**
Energy suppliers profit from selling more energy	Carbon emissions reduction target (CERT) Supplier Obligation Customer Levy (NI)	**Amber**
Risk and Uncertainty		
Uncertainty over future carbon price	Support for longer phases and clearer trajectories for the EU ETS	**Red**
Uncertainty over future energy price		**Amber**
Valuation of potential energy savings		**Amber**
Technical risks	Certification of micro-generation Trade bodies	**Green**
Option value of waiting		**Amber**
Length of tenure	Energy performance certificates Building regulations	**Amber**
Innovation		
Co-ordination of research	Funding of Energy Technology Institute	**Amber**
Route to market/ Pump priming	**For housing:** Low carbon buildings programme Reconnect Scottish householder and renewables initiative Environment and renewable energy fund(NI) 'Merton' rules **For Transport:** Low carbon vehicle innovation platform	**Amber**
Knowledge spillovers	Patents Funding of primary research International co-operation in R&D	**Amber**
Uncertainty over future carbon price	See "risk and uncertainty" above	**Amber**
Technology lock-in	Distributed generation policy	**Red**

What do policies need to deliver?

A discussion of the appropriate level of domestic CO_2 emission reductions is beyond the scope of this paper. However, consideration can be given to the technical abatement potential in the UK and the relative cost effectiveness. Arguably all “no regrets” measures[27] should be pursued regardless, because the benefits outweigh the costs. Where the UK has target levels of abatement, as outlined in Annex A, domestic abatement that costs less than the market price for international abatement would deliver a net financial benefit to the UK.

The Shadow Price of Carbon (SPC) is the UK government’s assessment of the additional damage cost of each additional tonne of carbon dioxide emitted. The cost of international abatement, reflected in the carbon price achieved through international trading mechanisms, would ideally approach this price in the medium term. Therefore measures costing up to the Shadow price of Carbon could be justified. The estimate of the shadow price is £29/t CO_2e in 2013 and £33/t CO_2e in 2020 (In 2007 prices). For domestic abatement options that cost more than this, they could arguably be justified on the basis of other benefits such as enhanced security of supply and their role in supporting innovation, and the development of new low carbon industries[28].

An assessment of the marginal cost of abatement in the case where the UK chooses to deliver a ‘demonstration project’ and reach its target levels of abatement domestically cannot be made here, though it would be likely to be higher than the SPC. However the ‘demonstration project’ would be counter-productive if it relied on relatively very high cost measures to be delivered in comparison to a more flexible international approach. This suggests that in the ‘demonstration project’ scenario that there would remain a limit on the cost of abatement that could be justified to deliver the majority of UK abatement.

The Energy White Paper (2007) provides information on abatement costs for some technological and policy options. These are listed in Table 8 below. It should be noted that this is not an exhaustive list of options, for instance it does not include product policy.

[27] Measures for which the cost per tonne of carbon abated is negative (the benefits are larger than the costs excluding any carbon benefit).
[28] Wider benefits, such as air quality improvements should form part of the calculation for costs of abatement. Only those benefits that are not quantified in abatement cost calculations should be considered to offer an additional justification.

Table 8: UK abatement costs for domestic emissions, (EWP 2007)

Method	**Abatement cost (£/t CO_2)**
Standard Insulation	-47.5
Better Billing for the domestic sector	-42
Domestic heating measures	-39.5
Solid wall insulation	-21.5
Domestic Lighting	-16.4
Real Time Electricity Displays	-10
Successor to voluntary agreements with car manufacturers	28.6
Renewable Transport Fuel obligation	47.7
Heat generating micro-generation	141.8
Electricity generating micro-generation	402

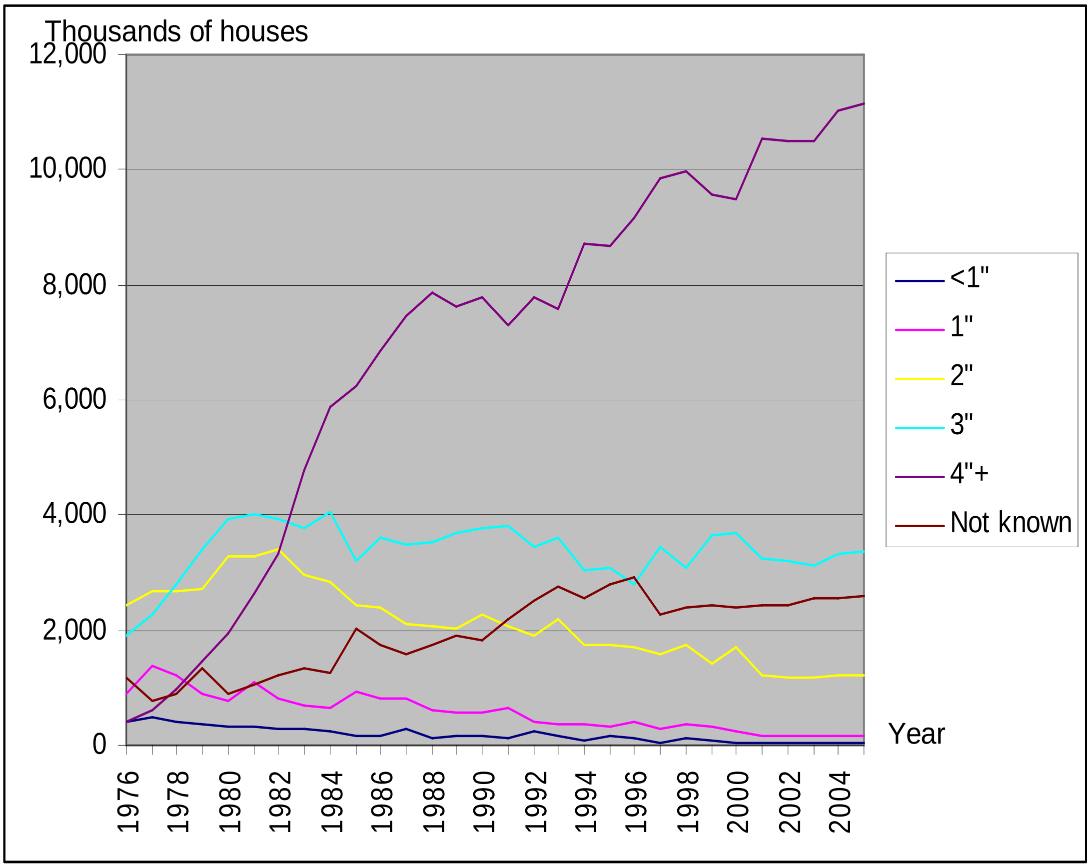
For those measures with a negative cost per tonne abated, the benefits of the policy, without including the benefits associated with reducing carbon emissions are greater than their cost. These are therefore 'no regrets' policies and measures. Even in the absence of any drive to reduce carbon emissions, it would be desirable for the UK to undertake them. If policies were undertaken up to the Shadow Price of Carbon it would provide justification for the successors to the voluntary agreements with car manufacturers.

How well cost effective abatement methods are being delivered provides a measure by which the current policy mix can be judged. Where there is a low level of delivery, a barrier or barriers are acting. A new policy that could effectively address these barriers would have the potential to add value.

Delivery of abatement methods by current policies

To assess the level of success of the current policy mix this section first looks at the trends in uptake of various abatement technologies. Considering the cheapest method first, standard insulation, overall there has been a dramatic increase in uptake since the 1970's. For loft insulation, 94% of houses in 2006 had it, as compared with 42% in 1974. Not only are more lofts insulated, but they are now insulated to a greater depth.

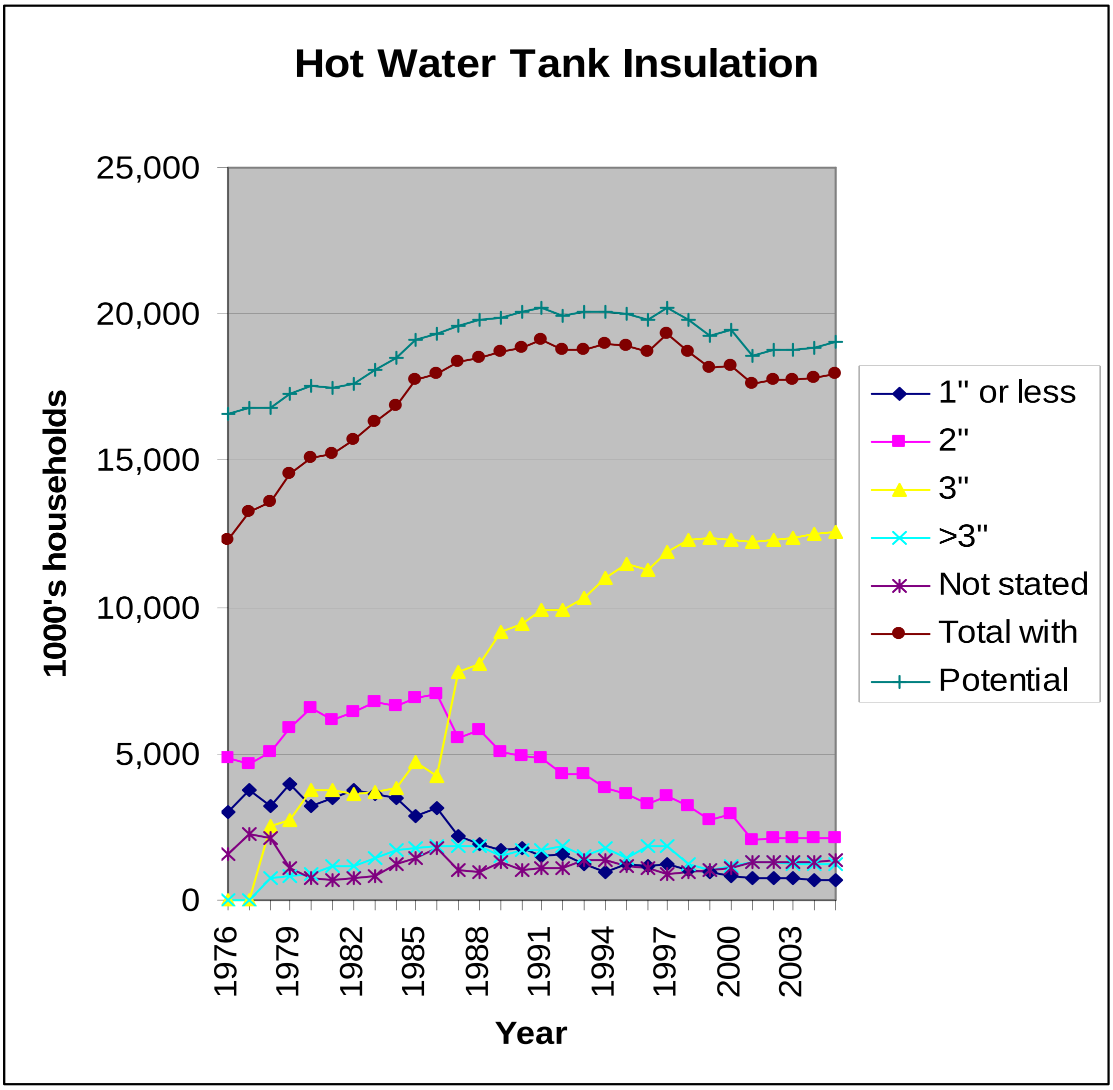
<u>Figure 4: Loft insulation trends</u>



(Figures from BRE 'Domestic energy fact file', 2006)

Yet this trend masks sectors of the housing stock where loft insulation has reached a lower proportion of houses. Whereas in owner occupier houses approximately 60% of houses have more than 4" of loft insulation – less than 30% of private rental properties do. This indicates that the barrier of split incentives has not been successfully addressed. Insulation of hot water tanks equally shows an increase in the level of insulation installed. Only a small fraction of hot water tanks are left with no insulation at all. Two thirds, in 2005 had greater than 3 inches of insulation.

Figure 5: Hot water tank insulation



(Figures from BRE ‘domestic energy factfile, 2006)

About 50% of cavity walls were left unfilled in 2004[29]. This overall figure once again masks variation by tenure, with over 70% of private rented accommodation having unfilled cavities. However looking forward, the Building Research Establishment (BRE) predicts that all cavities will, except in only a very few cases, have been filled by 2020[30]. Analysis by Defra for CERT indicates that cavity wall insulation will have been installed in almost all suitable homes by 2014.

These trends in standard insulation installation illustrate how present policies have already delivered a substantial proportion of the ‘low hanging fruit’; abatement that is easy and cheap to undertake. This is true of other abatement technologies too, since 2005 for gas and 2007 for oil, all replacement or new domestic boilers are required to use condensing boiler technology. Improvements in efficiency beyond this are limited, with approximately 85-92%

[29] Building Research Establishment, “Domestic Energy Fact File, 2006”
[30] Building Research Esablishment “Delivering cost effective carbon saving measures to homes”

of input energy converted into useful heat. Only by replacing boilers with renewable heat technologies (ground or air source heat pumps, biomass boilers), or district heating, could additional emission reductions be delivered.

The BRE report predicts that most cost effective technological abatement methods for the home will be close to exhausted by 2020. The remaining opportunities, aside from any new innovation will be unexploited potential from Solid wall insulation, floor insulation, efficient glazing and efficient white goods.

For solid wall and floor insulation, there are considerable costs to individuals undertaking these measures which are not taken into account in the analysis of their cost effectiveness. The cost effectiveness of these measures are overstated by not including the 'hidden' costs, such as taking a day off work to have measures installed, the loss of internal space, the covering over of a Victorian brickwork façade or the disruption of clearing rooms out. The 'hidden' cost arises due to an analytical failure, real costs are not factored in to the cost effectiveness calculations. This makes it difficult to assess the actual potential from these technologies, and may explain in part the lack of take-up. However, innovation could reduce these 'hidden' costs, by for example developing super thin solid wall insulation. As far as policy fails to nurture such innovation there is the potential for new policies to add value. The barrier may also be one of social inertia; lack of familiarity with the technology and low awareness of the energy savings that it could deliver. The BRE report notes the difficulty in assessing which barrier is most significant, and arbitrarily reduces the technical potential by half to reflect the 'hidden costs'.

The payback time for glazing is longer. As a result it is most likely to be improved at a time when windows are to be replaced or installed anyway, when just the additional cost of efficient glazing can be evaluated compared to that of less efficient glazing. Glazing in new build houses is subject to building regulations and since April 2002 all replacement double glazing window installations became subject to Document L of the Building Regulations too. This states that UPVC or timber replacement double glazing windows should not have a U[31] value higher than 2.0 W/m 2K and metal double glazing windows (aluminium) should not have a U value higher than 2.2 W/m 2K. This ensures that efficient glazing will be installed. Additional improvements could most easily be delivered by tightening these regulations.

Regulations also cover appliances. The EU directive on eco-design of energy using products provides a framework, within which over the next few years implementing directives will be published for all major categories of energy using appliances. Going forward, consumers will only have a choice of, by today's standards, relatively efficient appliances. Sales trends indicate that current policies are successfully increasing the proportion of appliance sales that are in the highest energy efficiency categories. A report for the market transformation programme makes the following projections[32]:

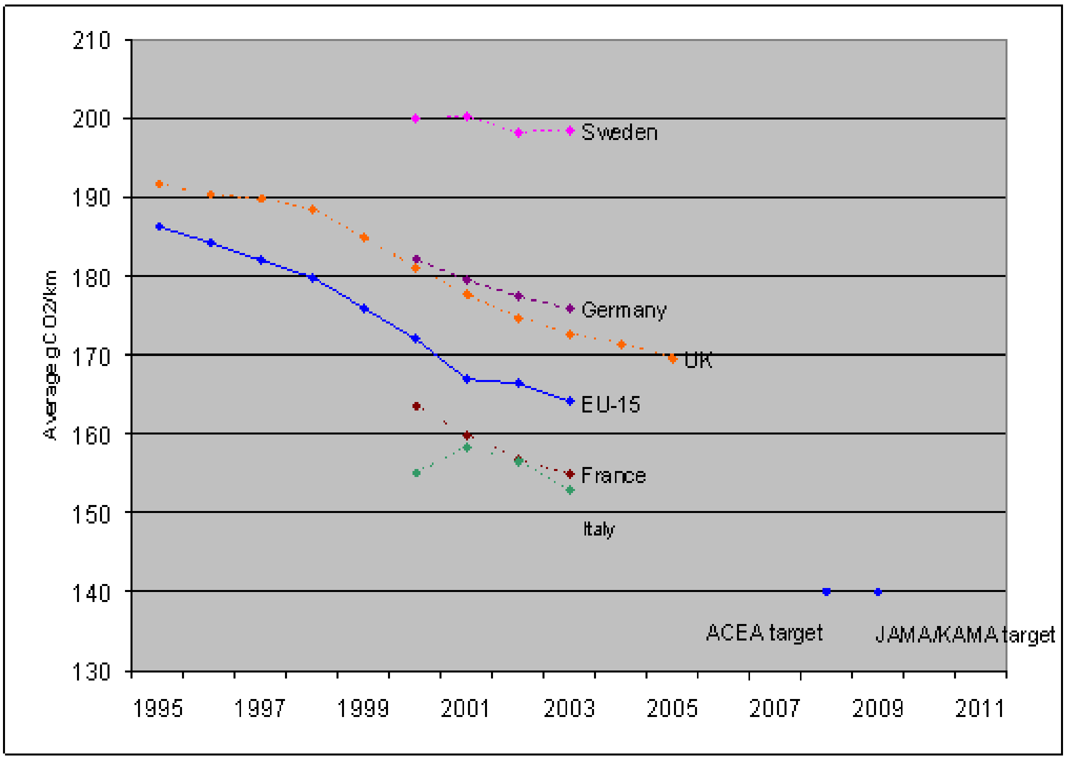
[31] U values are a measure of thermal conductance – the lower the value the lower the heat loss.
[32] "Sustainable products – improving the energy efficiency of energy using products" http://www.mtprog.com/ReferenceLibrary/Sustainable_products_consultation_Chapter_3_wet.pdf.

"2010: 50% of washing machines sales are A+ rated, 25% of tumble drier sales are heat pump and over 95% of dishwasher sales are A-rated.
2020: 100% of washing machines sales are A+ rated and 35% of washer driers sales are A+ rated.
2020: 75% of tumble drier sales are heat pump.
2020: a new dishwasher rating that uses 15% less energy than A rated is established and sales of these reach 70%."

Replacement of incandescent bulbs with compact fluorescent bulbs delivers up to an 80% reduction in the energy used to deliver the same level of lighting. It is expected that this technology switch will be given a significant boost with a voluntary agreement to phase out the sale of incandescent bulbs in 2011. Further reductions from energy used for lighting may be possible as LED technology matures, but a significant proportion of the potential reductions will be delivered by present policy.

A voluntary agreement at EU level with car manufacturers has seen an improvement in the efficiency of new cars sold in the European Union. Future agreements will see a further tightening of the standards required. Proposals released in December 2007 indicate a move to a target average level of emissions from vehicles of 130g/km by 2012 from fuel efficiency alone with a further reduction of 10g/km coming from bio-fuels and tyre improvements. The agreement will be mandatory with a penalty of €95/g CO_2/km/car over the target. Proposals for the EU fuel quality directive propose a 10% reduction between 2010 and 2020 in the lifecycle emissions of road transport fuel.

Figure 6: Road passenger vehicles efficiency trend



(DfT 2006)[33]

In summary, new policies have limited potential to add value by increasing the uptake of cost effective technological measures as these measures are predicted to be largely adopted under the current policy framework. Where they are not adopted, it will largely be because of specific barriers, particularly split-incentives, lack of innovation targeting the reduction in 'hidden costs' and lack of awareness. The lack of awareness could be in terms of the unfamiliarity with certain abatement methods, such as under-floor insulation, or of the level of savings delivered by measures. New policies that aim to deliver additional low cost technological abatement would be most effective where they target these barriers.

Emissions and Energy Service Demand

Policy can also deliver abatement by changing individuals' behaviour in a wider sense than just their choice of technologies by encouraging individuals to reduce their demand for energy services. Behaviour change in the context of energy services is potentially another orchard of low hanging fruit that remains largely unpicked. The reduction in demand for energy services could arise both through a change in the level of useful energy services that people demand, and through a reduction in the amount of energy service that they waste. Lowering the demand for useful energy services could be achieved for example

33 http://www.dft.gov.uk/consultations/archive/2006/reducingnewcarco2emissions/reducingnewcarco2emissionswh1748?page=2#a1004

in terms of how people travel, how large and warm a house they wish to live in, where they choose to holiday, or how many appliances they have in their home. Examples of how a reduction in the waste of useful energy services could be achieved are: individuals turning lights off as they leave a room, not leaving appliances on stand-by, re-setting their heating controls when the house is empty, or pumping up their car tyres. The following equation for the level of emissions highlights the importance of energy service demand:

Emissions = Carbon\ Energy Generated X Energy Used\ Services Consumed X Energy services consumed

Carbon intensity of energy X Energy Efficiency (number smaller if more energy efficient) X Energy Services

Overall Energy Demand

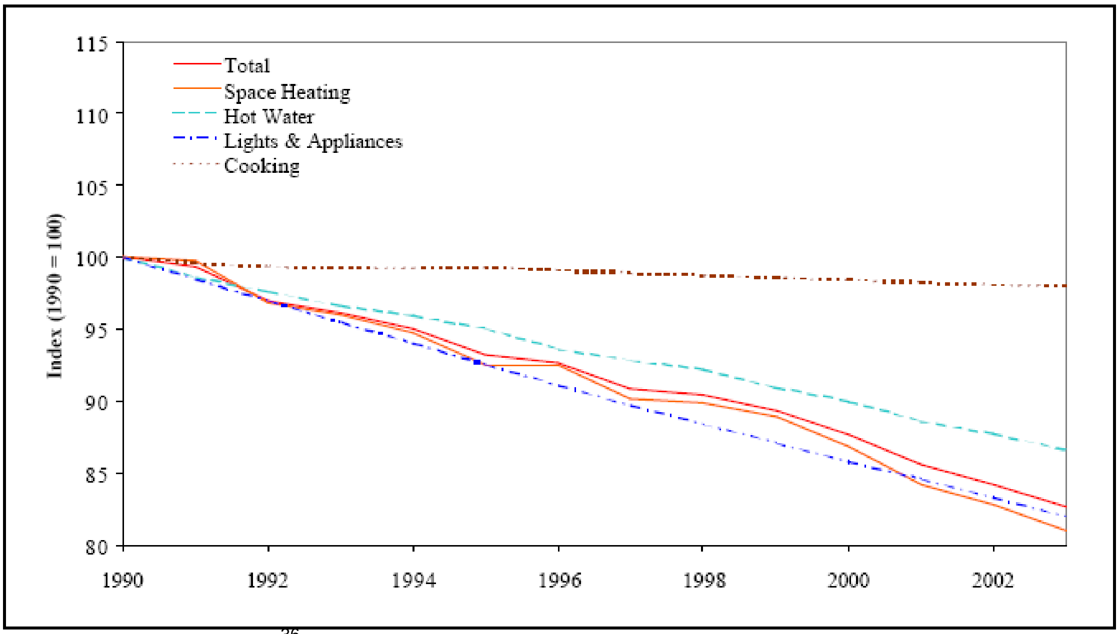
The importance of addressing the issue of the level of demand for energy services is underlined when it is considered that adoption of technological measures are successfully resulting in increasing energy efficiency in the UK, but the level of overall energy demand has increased from 204.5 MtOe in 1980 to 232.1 MtOe in 2006[34]. During the period, energy demand increased at an average rate of 0.5% a year. This is because while energy efficiency has improved, the demand for energy services has also increased and at a faster rate. For a given carbon intensity of energy, a rise in energy demand will create a rise in carbon emissions. For emissions to fall, a de-carbonisation of the energy supply in the UK would be necessary. Without a stabilisation in the overall energy demand in the UK, the Climate Change Bill target reductions will be challenging or require significant international abatement to achieve.

An example of growth in demand for energy services was highlighted by the Energy Saving Trust in their report on the revolution in consumer electronics that is driving an increasing demand for energy to power products used for information, communications and entertainment[35]. The report predicts that 45% of domestic electricity use will be for these products by 2020. Many of the products are providing energy services that no-one demanded a generation before. Regulations that improve the efficiency of appliances on the market, do not address the issue of people buying more appliances, more televisions in the home, more fridges, more lighting. After domestic insulation is improved, the theoretical savings in energy will not be completely realised if householders react by increasing the average temperature of their home. Demand for more energy services rises not only as they become cheaper due to energy efficiency improvements, but also because economic growth creates more purchasing power.

[34] DBERR, “UK Energy in brief” July 2007.
[35] Energy Saving Trust, “The Ampere Strikes Back” 2006

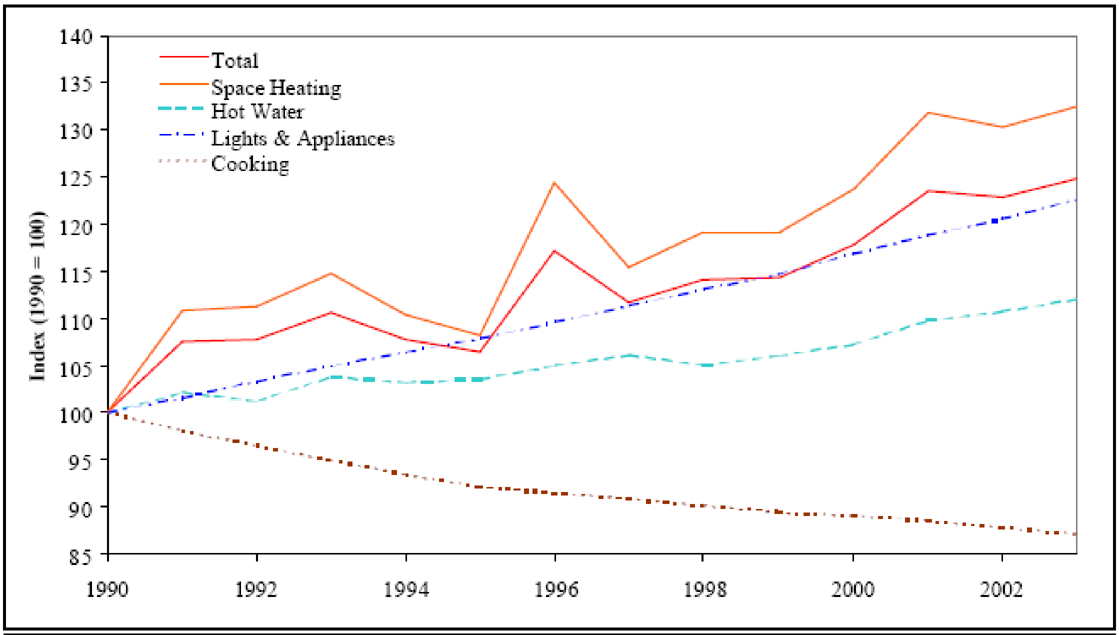
Figures 7 and 8 decompose for the household, the total energy demand into the two separate factors; energy efficiency and demand for energy services. The figures illustrate that the level of energy required to deliver a fixed level of energy service is steadily declining – progress is being made in energy efficiency. However the figure 8 illustrates that there has been a continual increase in the level of energy services that are being demanded.

Figure 7: Energy efficiency (specific energy consumption)



(DBERR/DEFRA 2005)[36]

Figure 8: Energy service demand per household



(DBERR/DEFRA 2005)

[36] http://www.berr.gov.uk/files/file19842.pdf

Outside of the house, the same increase in demand for energy services is also evident. The Department for Transport forecasts that miles driven by personal cars will increase by 33% between 2003 and 2025[37]. There is a projected increase in flights of 70% between 2007 and 2030[38].

If growth in the demand for energy services outstrips the improvement in energy efficiency, emissions can only be reduced by a transition to clean and lower carbon energy sources. Though fossil fuel switching can be helpful here, much of the potential, at least in the power sector has already been realised with the 'dash for gas'. A move to increase the use of combined heat and power could also deliver some lower carbon energy, and nuclear energy may play a role. However, much of the improvement in the cleanliness of energy in the UK would have to be achieved by a switch to renewable energy or the development of Carbon Capture and Storage.

Carbon Capture and storage remains an unproven technology and though it may play a significant role in reducing emissions in future, it is unlikely to play a significant role for the UK in the next twenty years. The UK in 2006 produced only 1.8% of its energy from renewable sources[39]. The expansion of this sector is anticipated, with the EU adopted target for 20% of all EU energy to come from renewable sources by 2020 requiring 15% of UK energy consumption to be from renewables in 2020. As a proportion of UK energy, renewable energy must increase by 13%.

Though there are no published estimates of the cost to the UK of this target, the scale of the costs can be conceptualised by considering the costs associated with the Renewables Obligation on electricity suppliers. While electricity represents 17.5% of UK energy use, the provision of 4.55% of this electricity from renewables is estimated to be costing an additional £800 million pounds a year to energy consumers. The Renewables Obligation results in only 0.8% of UK energy being delivered from renewable sources. This is enough to contain less than two years growth in the overall energy demand in the UK, without there being a growth in emissions. Should energy demand continue to grow at 0.5% a year from 2008 until 2020, energy demand would have increased by just over 6%. Just to keep emissions constant would require significant investments in lower carbon energy, and roughly half of the benefit from achieving the UK's contribution to the EU 20% renewable energy target would be offset by the increase in demand for energy services.

Behavioural changes that reduce the demand for energy services are apparently low cost; if a policy were implemented that could remove the barriers to such changes it would have the potential to deliver significant additional low cost abatement. However, caution must be exercised here when considering the cost of behavioural changes. Some changes may indeed be low or no cost; for instance, remembering to turn off the lights when leaving a room, cycling or

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[37] Department for Transport, "National Transport Model" 2007
[38] Department for Transport projections 2007
[39] 'Digest of UK energy statistics 2007', BERR.
http://www.berr.gov.uk/energy/statistics/publications/dukes/page39771.html

walking rather than driving to the local shop. There may be an initial cost in effort to change habits, but after a short time switching off the lights could become automatic and cycling to the shops could be found to have a net benefit not just through the cost of fuel saved, but in terms of health benefits. For other behavioural changes though, there would be ongoing ‘hidden’ costs. For someone choosing not to fly to Australia to see their sister, this decision would not be cost free. How high the cost would be would depend on how much they valued the opportunity to see their sister. For someone turning their electronic appliances off at the wall, this may carry an ongoing cost in terms of the inconvenience involved. For an individual who chose not to make these changes it may not represent an irrational failure to exploit a low cost abatement opportunity, but instead a rational decision based on how much they value their time or their relationship.

How much abatement is available from low cost behavioural change depends on the size of these hidden costs, but it is estimated that in the UK there is significant potential. Darby notes[40]:

“[Energy] Consumption in identical homes, even those designed to be low-energy dwellings, can easily differ by a factor of two or more depending on the behaviour of the inhabitants”

Behaviour could be influenced by policies that provide more information and feedback on energy use in a way that engages individuals and increases their awareness of their personal emissions and the link to climate change. In short policies that increase the **visibility** of emissions and its impact will have a potential to add value to the policy mix. There are existing policies in this area (see table 6 above, policies that impact on the psychological/ sociological barrier). Additional policies would add value by how much and how engagingly they raised the visibility of emissions, and the extent of emission reductions as a result of behavioural change. The added value would be quantified in terms of how much additional low cost abatement this behavioural change caused.

In summary, successful new policies would need to deliver a further reduction in barriers to the uptake of energy efficient technology or behaviour change. For the uptake of technological improvements, policy is generally delivering well, though there is evidence that specific barriers could be addressed more effectively; notably split incentives, and barriers to innovation. For behavioural changes that would result in a lower demand for energy services, it is less clear that the present policy mix is successfully delivering. There is apparently another orchard of ‘low hanging fruit’ to be picked if policy can effectively address the barriers that result in cost effective behavioural change not being made. However, this orchard may to an extent be illusory, due to the failure for cost-effectiveness analysis to account for real, but hidden, costs.

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40 “The effectiveness of feedback on energy consumption” 2006.
http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

Policies that raise the **visibility** of personal carbon emissions will play a key role in government policy in this area. If individuals are fully aware of their energy use, its cost, its associated emissions, the link between these emissions and climate change, and the available technologies and lifestyle changes that could reduce their emissions, then any continued demand for energy services can be seen as a fully informed choice. Only by increasing the cost of energy would such individuals be likely to further reduce their demand for energy services. This raises three questions:

- How far from being fully informed are people?
- How much would demand for energy services change if people were fully informed?
- How much closer to being fully informed would the introduction of personal carbon trading make people?

Emissions Projections

Central emissions projections for the UK, including credit for international effort, $MtCO_2$, these figures include all planned and funded policies in addition to those currently in operation:

Table 9: Overall UK carbon dioxide emissions

	1990	2010	2013	2015	2020
UK emissions	590	497.6	489.7	484.4	463.9

(Source: BERR 2007, 2013 figure interpolated. Emissions in $MtCO_2$/year)

To achieve the Climate Change Bill targets for UK emissions, emissions will need to be **438.2 $MtCO_2$ in 2020**, and below **236.8 $MtCO_2$ in 2050.**

Coverage of personal carbon trading

The coverage of a downstream trading system will depend on when it is introduced and which sectors are included. The following figures provide projections for possible sectors to be included were a personal carbon trading system introduced.

Personal Vehicle Use

Personal vehicle transport projections are provided by the National Transport Model at the Department for Transport. In summary, the expected increase in fuel efficiency of vehicles is largely counter-balanced by an increase in transport mileage over the period to 2025, which is forecast to rise by 33% between 2003 and 2025. In the road transport sector, an overall reduction in CO_2 of 0.9% is forecast for the whole period. The trend for personal vehicle leisure use is broadly similar, with a 4.5% overall drop in carbon emissions for the whole period. Table 10 provides projections until 2020.

Table 10: Personal vehicle emissions

	2003	2010	2013	2015	2020
Personal car use	60.1	61.2	61.5	61.8	57.5

(Source: National Transport Model, DfT,2007. Emissions in $MtCO_2$/year.)

Leisure Aviation

Leisure Aviation is used here to define the use of air travel by UK citizens for non-business purposes where the flight is domestic, or international. The UK emissions projections for aviation include only international departures and domestic flights (Table 11). In order for personal carbon trading to create a sense of responsibility for emissions from flights, there is a case for including UK leisure emissions from international arrivals as well.

Table 11: Leisure aviation emissions

	1990	2010	2013	2020
Aviation emissions, international departures, and domestic	16.9	37.5	40.2	50

(Source: "UK Air Passenger Demand and CO_2 Forecasts"[41], DfT, November 2007. 2013 figure interpolated. Emissions in $MtCO_2$/year.)

The Department for Transport have carried out analysis (September 2007) of the proportion of these emissions that are domestic or international, as well as what proportion of these categories consists of UK leisure travel (Table 12). 93% of these emissions arise from international departures, 7% from domestic flights. UK leisure makes up 50% of domestic flight passengers and 64% of international flight departures.

Table 12: Disaggregated leisure aviation emissions

	1990	2010	2013	2020
UK leisure (domestic)	0.6	1.3	1.4	1.8
UK leisure (international departures)	10.0	22.3	23.9	29.8
UK leisure (domestic and international departures)	10.6	23.6	25.3	31.5
UK leisure				

41 http://www.dft.gov.uk/pgr/aviation/environmentalissues/ukairdemandandco2forecasts/airpassdemandfullreport.pdf

(domestic, international departures & arrivals	20.7	46	49.3	61.3

(Source: DfT, 2007. 2013 figure interpolated. Emissions in $MtCO_2$/year.)

Residential Energy Use

Emissions projections from residential energy use are provided by DBERR.

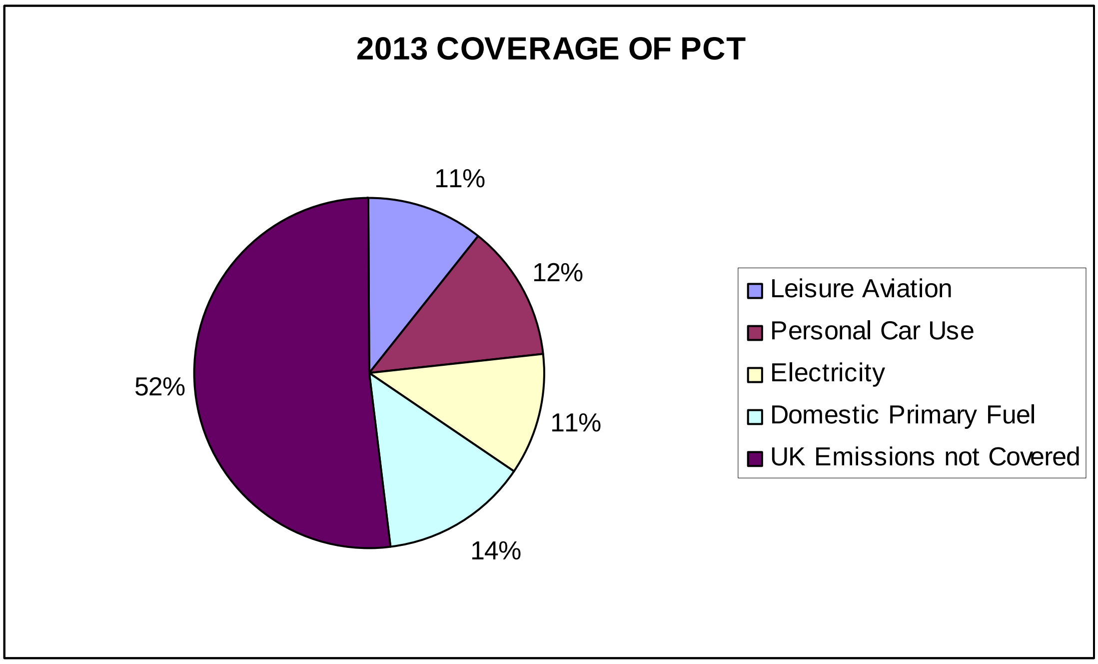
Table 13: Residential emissions

	2010	**2013**	**2015**	**2020**
Residential Electricity Use	56.8	54	52.1	44
Residential Primary Fuel Use	72.2	67.7	64.7	55

(Source: BERR 2007. 2013 interpolated. Emissions in $MtCO_2$/year.)

At present roughly 55% of residential energy use is for space heating, 20% for water heating, 25% lighting/ appliances/ cooking (Figure 9). These proportions may change as appliance use continues to grow yet energy use for space heating reduces. The following pie charts illustrate the proportion of UK emissions that would be covered by a personal carbon trading scheme under different formats.

Figure 9: 2013 coverage of personal carbon trading



4 Additional cost effective abatement?

Having assessed the nature of the existing policy strategy, the question of how effective an additional contribution personal carbon trading would make can be assessed. Personal carbon trading would increase the supply of domestic abatement in the UK in so far as it further reduces barriers to the adoption of cost effective abatement. A first area to consider is which barriers personal carbon trading addresses and how it might work to reduce them. Some fundamental economic considerations that question how effective the personal carbon trading mechanism would be at reducing these barriers are also considered. The strategic fit of personal carbon trading is then approached from the perspective of how it will interact with specific significant policies that will either co-exist with it or have had a significant impact on the remaining cost effective abatement potential in the UK.

Barriers addressed by Personal Carbon Trading

Personal carbon trading would act on two types of barriers:

- It would be experienced at the micro-level as a carbon price. Carbon emissions are an economic bad (externality), without a carbon price the cost of the damage they do is not paid by the individual choosing to buy the fuel or undertake the activity that produces them. This will lead to an underinvestment in technology or behaviour change that reduces their level.
- It would increase the visibility of personal carbon emissions, increasing awareness. Increased awareness could motivate behaviour change, both in terms of choosing to buy or install technological abatement measures, but also in terms of motivating individuals to adopt lifestyles which demand a lower level of energy services. Greater awareness would be expected to result in individuals reflecting on their energy use and the associated emissions and considering ways to reduce their emissions in a way that is cost-effective to them.

Creating a Carbon Price

Assuming the cap on personal carbon emissions is set at below the level of emissions that would be produced under business as usual; allowances will have a value in the market place. This market price for allowances will create an additional cost to individuals producing carbon emissions. The carbon price will result from either the direct cost or an opportunity cost. Direct costs arise where individuals have used up all the allowances that they were allocated so that further production of personal carbon emissions will result in their having to buy additional allowances from the market. There is also a cost for individuals that still hold some of the allowances that they were allocated. When producing emissions, they will have to surrender allowances which means that they forego the opportunity of selling them on the market.

If personal carbon trading was implemented covering domestic energy use, road transport fuel and aviation an increase in cost would be created for each of these sectors in proportion to the carbon intensity of the source of emissions. For some of these sectors this would create the first carbon price, most notably for domestic primary fuel use, but for others it would be additional to a carbon price created through other trading mechanisms. Electricity prices carry the passed through costs of EU ETS allowances that were required for its generation, and by 2013 aviation will also be covered by the EU ETS. There is no explicit carbon price for road transport fuel, but there is a high level of taxation already in place.

The price signal would encourage individuals to substitute away from activities that created personal carbon emissions. As using carbon rich energy became more expensive it would make using it less attractive than before. Only if the benefit to the individual was high enough to justify the cost of both the energy and the carbon price would the individual continue to produce the carbon emissions. Measures that reduce carbon emissions would also have a greater financial return; it would shorten the payback time for investment in technological abatement. Installing loft insulation would not only save an individual the cost of the gas (assuming the home has gas heating), but the cost of the allowances associated with the quantity of gas saved.

The impact of the price signal will depend on how large it is, and how responsive individuals are to the change in price. Alternatively, for a hard cap scheme, how high the price will have to go to have sufficient impact for emissions to stay within the cap will depend on how responsive individuals are to the price signal. If the cap on personal carbon emissions were a ‘hard’ cap, with no possibility of extra allowances being issued, then the price of allowances could in theory go up without limit. It could not be known in advance of the introduction of the scheme how high the price would have to go, in combination with the raised awareness personal carbon trading would bring, in order to reduce the level of personal carbon emissions sufficiently for them to stay within the overall cap. However, uncertainty about how high the price of allowances may go poses a political risk that makes it unlikely that a hard cap would be used.

The possibility of high allowance prices creates a number of problems. Firstly, high prices would exacerbate the impact on fuel poverty. The top 20% of energy users in the lowest income decile use more than twice the energy of the bottom 20% of energy users in the highest income decile[42]. The cause of this high energy use is, in many cases, poor quality housing stock, without the capital to improve it (or much of an incentive in the case of tenants with expectations of short tenure). This can be compounded where the housing is in an area that is poorly serviced by public transport. Those with high energy use and low income are those that are the most vulnerable to high allowance prices. They will be net

[42] “Economic instruments for a socially neutral national home energy efficiency programme” Dresner and Ekins, 2004.

purchasers of allowances, as their energy use is above average, and the proportion of their income that will be taken up by paying for these additional allowances will be higher than for those in higher income groups. As the allowance price increases, an increasing number of individuals will be driven into fuel poverty by the personal carbon trading scheme.

This is a political problem, and is one that could be mitigated through a complimentary expansion of funding for fuel poverty schemes and by any success of existing fuel poverty schemes. However it will remain a real political motivation to soften the cap on the number of allowances.

High prices for allowances would also create unpopularity for the scheme, particularly if it becomes clear that individuals are paying significantly more for the right to emit than businesses are through international trading schemes. High prices are also likely to show more absolute volatility. This would create the potential for more significant losers from the scheme who sold their allowances at the wrong time (and price). Volatility would also create more uncertainty and risk for individuals. By setting a hard cap, the government would effectively transfer the risk as to the cost of meeting their targets to individual households. Furthermore, a high price would be out of line with the governments own assessments of the damage cost from carbon emissions, the shadow price of carbon. It would be difficult for the government to defend individuals paying more for the right to emit carbon dioxide than their estimate of the damage caused by their emissions. Finally, it has been shown (Annex A) that the financial benefit to the UK from additional abatement is equal to the displaced cost of international abatement. If the price of personal carbon trading allowances is above the price of international abatement, then it will drive individuals to undertake methods of abatement that carry a greater cost than the benefit they bring to the UK. Unless the government has chosen to deliver the UK ‘demonstration project’ thereby placing a value on the role model and leadership this would create, this will increase costs to the UK and reduce the UK’s overall welfare.

For all the above reasons, it is unlikely that personal carbon trading (or indeed an upstream trading scheme) could be introduced with a hard cap. A more flexible cap would require the creation of a ‘safety-valve’ or buy out mechanism, whereby once the price of allowances reached a ceiling price; further allowances would be made available. This could take the form of a buy only mechanism with the EU ETS, as has been proposed for the Carbon Reduction Commitment, or alternatively the government could issue unlimited personal carbon trading allowances at the ceiling price. The additional revenue from such a sale could be hypothecated to pay for additional energy efficiency measures. Whichever mechanism were chosen, it would mean that one of the claimed benefits for personal carbon trading would not hold; that it would deliver certainty over the level of personal carbon emissions.

The Shadow Price of Carbon is £29/t CO_2 in 2013 and £33/t CO_2 in 2020. The price of personal carbon trading allowances is unlikely to be higher than this level given the reasons above. It is instructive to consider how significant the price signal would be to individuals were the price of allowances to reach these maximum levels. A £30 allowance price would have the following effects on the sectors covered by personal carbon trading [43]:

- An approximate 7% increase in petrol prices.
- An approximate 10% increase in airline ticket prices.
- An approximate 15% increase in domestic electricity prices
- An approximate 15% increase in domestic gas prices[44].

This level of price increase is unlikely to create a significant shift in demand. A 7p a litre increase in the price of petrol is well within the level of price volatility for petrol resulting from changes in the oil price. Recent jumps in the oil price, and consequent increases in petrol prices have shown demand for petrol to be highly price inelastic, at least in the short term. Airline tickets have come down by more than 10% due to the arrival of low cost airlines, a 10% increase is unlikely to impact significantly on demand growth for flights. As people become wealthier, one of the most common aspirations is to travel. Similarly, demand for domestic energy has shown itself to be highly price inelastic, at least in the short term. A 15% price rise is unlikely to be sufficient to drive a significant reduction in demand. A report by NERA and Enviros for Defra in 2006 commented:[45]

"Studies concur in the observation that the price elasticity of energy demand typically is low compared that of many other goods. This can be interpreted as an indication that energy has few immediate substitutes and that it is difficult and costly for energy consumers to reduce their energy consumption."

Long term demand elasticity for domestic energy consumption was estimated at -0.3. A 15% rise in price would therefore only produce a 4-5% drop in long run energy demand. Though the creation of a carbon price for domestic energy use will create greater consistency with other sectors of the economy, it can be seen that in these sectors, a carbon price up to a level of £30/t CO_2, is unlikely to drive significant additional abatement. Furthermore, if it was the case that the main added benefit from personal carbon trading was the creation of a carbon price, then policies such as carbon taxes or upstream trading would be simpler.

<u>The quality of visibility delivered by personal carbon trading</u>

The creation of a carbon price by personal carbon trading is unlikely to drive significant additional abatement at politically acceptable levels. The creation of a carbon price is also not going to be sufficient to justify the implementation of personal carbon trading, as there are simpler ways of achieving this. As a result, the key to whether personal carbon trading will deliver sufficient domestic

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[43] These percentage increases assume that, in real terms, costs of these forms of energy and aviation remain constant.
[44] Author's calculation, based on carbon emission factors for fuels and current retail prices.
[45] "Policy options to encourage energy efficiency in the SME and Public Sectors", p26. http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/policyoptions-0611.pdf

abatement, to justify the costs of implementing it, is how effectively it increases the visibility of personal carbon emissions. Raised visibility is not an end in itself, but rather a means to increase individuals' awareness of their personal carbon emissions and as a result create behavioural change. Sarah Darby[46] in her report on the effectiveness of feedback on energy consumption noted:

"Most domestic energy use, most of the time, is invisible to the user. Most people have only a vague idea of how much energy they are using for different purposes and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures. Hence the importance of feedback in making energy more visible and more amenable to understanding and control."

Personal carbon trading could provide three different types of visibility:

- Indirect aggregate feedback at the point of payment
- Feedback to an individual on their overall carbon footprint
- Provision of a 'stop and think' moment at the point of payment.

Indirect aggregate feedback refers to the fact that at the point of payment the emissions associated with the purchase would be made visible. The feedback will not make the real time level of energy use visible. For instance, an individual buying petrol would be required to surrender or purchase allowances to match the emissions associated with the quantity of petrol. This provides them with aggregated information about their emissions; they will know that by the time that they fill up again they will have caused roughly this level of emissions. However this does not provide information about the level of emissions at any given point during a driving trip or create awareness of inefficient driving habits, such as revving the engine when starting off, but could encourage an awareness of the carbon emissions associated with the fuel used. The type of visibility create for domestic energy would be even less direct. Visibility of the level of emissions over each billing period will be provided, but no information will be provided to individuals about real time electricity or gas use.

As well as providing indirect feedback on each type of energy use, personal carbon trading would provide feedback about how an individuals' emissions compared to the national average. Individuals would be made more aware of their overall carbon footprint. This may result in additional behavioural change, such as for those that realise that they are responsible for a significantly larger than the average level of emissions.

Personal carbon trading would provide a 'stop and think' moment as individuals purchase energy through the additional transaction with carbon allowances at the point of sale of energy or flights. This has the potential to further raise awareness. There would be an optimal level of hassle for the additional transaction, which should be a consideration for the design of the payment infrastructure. Too little hassle and the prompt to stop and think would be

[46] http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

reduced; a potential downside to the use of smart cards. On the other hand, too much hassle and there would be an increased incentive for individuals to disengage from the scheme.

Additional visibility?

The additional benefit that the raised visibility and awareness personal carbon trading will deliver can be challenged. Personal carbon trading would only add value to the extent that it increased visibility beyond that delivered by other policies. There are other existing and planned policies that are targeting an increased level of awareness for individuals of their level of emissions, some of which will create not just indirect feedback, but real time information on energy use. In addition, the visibility benefits of personal carbon trading will only exist while individuals remain engaged with the scheme. It could be rational for a proportion of individuals to decide to engage as little as possible with the scheme. Finally, the visibility may drive 'irrational' trading, which would increase the overall cost to the UK of it achieving its emissions reductions targets.

Where other policies will deliver an increase in visibility, personal carbon trading will be able to add less value. In addition, it is not only policy that could raise the visibility of personal carbon emissions; the last two years has seen a step change in the level of media coverage devoted to climate change. This increased coverage has had an impact on the level of awareness of carbon emissions amongst the general public. This increased awareness has led more individuals to find out more about their own personal responsibility for climate change, and to take pro-active steps to find out what their level of personal carbon emissions are. This general improvement in the level of awareness of climate change has an impact in terms of raising the baseline level of awareness from which personal carbon trading could add value. If climate change maintains a high profile, it can be expected that the level of awareness will continue to increase.

Some government policies provide educational tools for those that are interested in finding out more about their emissions. For instance, the 'Carbon Calculator' allows an individual to make an approximate calculation of their overall level of carbon emissions, or the 'Transport Direct' website enables a rough calculation to be made of the carbon emissions associated with particular journeys.

Consultation is presently underway on the introduction of 'smart-metering' for domestic consumers of gas and electricity. The precise nature of these smart-meters is yet to be decided, but the aspiration is to have them installed in all homes by 2017. In addition to this, from 2008 for 2 years, domestic electricity customers will be able to request a real time display unit free of charge. This real time display unit will provide moment by moment feedback on the level of electricity use in the home, as well as information about cumulative level of electricity consumption over the previous day, week, month or year. The level of energy use can be displayed in terms of the quantity of energy, or in terms of the associated level of carbon dioxide emissions. Smart-meters will enable billing to be improved with a significantly more detailed breakdown of the energy use in the home. These measures will significantly increase the visibility of energy use in the home and the associated emissions. They will inform all consumers, as well as providing a tool through which those who are interested can gain a more detailed understanding of the precise nature of their energy use, and consequently areas where they could reduce it.

The additional visibility benefits of personal carbon trading for domestic energy use will be nil through its provision of indirect feedback. Smart-metering and the improvement in billing will provide an improvement in the visibility of personal carbon emissions beyond that which could hope to be supplied by personal carbon trading. Personal carbon trading would still provide some additional visibility as a result of its joining up domestic energy use with personal transport emissions, though to an extent smart-metering would provide some of the information on overall carbon footprint created by personal carbon trading by joining gas and electricity emissions.

This leaves additional visibility in the areas of road transport fuel use, and emissions associated with aviation. However, here it must be considered whether most of the visibility benefits could not be delivered more cheaply by other policies. While personal carbon trading provides indirect feedback about the level of emissions associated with road transport fuel, a regulatory requirement to have all petrol pumps display the level of emissions associated with a purchase could achieve the same indirect feedback. Receipts for the purchase of road transport fuel could also carry information about the level of carbon dioxide that the purchaser is responsible for. Similarly, regulations could increase the visibility of the emissions associated with flights. The cost of these measures would be a fraction of those involved with implementing a personal carbon trading scheme and would deliver similar indirect feedback benefits of personal carbon trading.

From the three categories of visibility that personal carbon trading would deliver, indirect feedback, feedback on an individual's overall carbon footprint, and a 'stop and think' moment, the implementation of personal carbon trading based on the first could not be justified. It will either already be being provided or could be provided more cheaply by other means. This means that the justification of personal carbon trading must rest on the last two categories of visibility and their potential to raise awareness and thereby change behaviour.

The carbon calculator enables interested individuals to achieve an overall awareness of their carbon footprint. The calculator scheme however is voluntary and as such will not educate and raise the awareness of large sections of the population. Personal carbon trading's additional effectiveness will rely on this increased awareness for these sections of their overall level of personal carbon emissions, and the impact on all individuals of the prompt to 'stop and think'. The increased awareness may drive individuals to take steps to bring their emissions closer in line with the national average, or even challenge them to take them below. Where this additional abatement is low cost, then personal carbon trading will have delivered a benefit to the UK.

In practice personal carbon trading may not, in all cases, provide very accurate feedback to an individual on their personal carbon footprint. If individuals make use of the ‘pay as you go’ option at all, then not all of their carbon use will be recorded on their account. It would only require an individual to leave their carbon card at home on a couple of occasions for the feedback on total carbon footprint to be inaccurate. In addition, where energy use is partly for business purposes, issues will arise. For instance, it would be difficult for an individual with a car that is used both for business and personal to surrender the appropriate level of allowances to match their personal use of the vehicle. Similar issues arise for people that run their own business from home in considering the proportion of domestic fuel and electricity are attributable to the business. A final issue arises when considering multiple occupancy homes. To an extent personal carbon allowances would be pooled. A couple living together would be likely to pay bills using whatever allowances they have to hand. This may not reflect their individual responsibility for the emissions; it could be the bill payer’s partner who likes to live in a 24 degree house. It may be simpler for houses with several tenants, such as student houses, to pay as they go rather than to try and gather together not just the money from housemates but also arrange the transfer of carbon credits to the bill payer. In all of these cases, the individual’s feedback on their overall carbon use will be blurred.

Engagement with personal carbon trading

There is an assumption about individuals’ level of engagement with the scheme in order for the visibility benefits to be realised. The assumption is that individuals will surrender their allowances over the course of a year, using their carbon allowance when purchasing road transport fuel, or when settling their utility bill. The engagement with the scheme would ensure that individuals were aware not only of how much carbon they generated and through which activities, but also how their level of emissions compared with the national average. However, it is possible that upon implementation of a personal carbon trading scheme, individuals would choose to have as little involvement with the scheme as possible. An analysis of the incentives for individuals to engage with the scheme reveals that it may be rational to sell all allowances immediately and then use the ‘pay as you go’ option.

A feature of the design of a personal carbon trading scheme is that individuals who had run out of carbon allowances, or had left their carbon card at home, would be able to buy the required allowance from the market, at whatever the prevailing market price was. This would also enable foreign visitors to buy fuel and airline tickets when in the UK. For example, consider someone filling up their car. At the checkout they would pay an amount equal to the combined cost of the fuel, and the additional cost of the carbon allowances required to cover the purchase. The transaction, from the perspective of the individual, would involve a single operation; paying the money. This is simpler than for the individual who carries their carbon card with them to the petrol station. They would be faced with two operations; the payment of the sum of money that is requested, but also the surrender of the carbon allowances. The scheme places costs on the individual, extra transaction costs, in terms of time and the costs of being organised. Unless they are sufficiently rewarded, this could lead to individuals disengaging from the scheme.

Richard Starkey, from the Tyndall Centre for Climate Change Research, has suggested that for individuals who find personal carbon trading too complex, an option would be to sell all their allowances immediately and then to simply pay the market price for carbon whenever they make any purchases covered by the personal carbon trading scheme. He has pointed out that this would also be an option for those wishing to minimise their involvement with the scheme[47]. This would change the experience of the scheme into one very similar to an upstream trading scheme. Unless there is sufficient incentive to hold on to the allowances the benefit of simplifying one's life would make it rational to sell the allowances.

If the market for allowances is working efficiently there would be only a very small incentive to hold onto allowances. As with most markets, the price of carbon allowances may go up, or they may go down, but the expectation would be that they would rise in price, through a year, by an amount somewhere close to the level of interest rates. The amount received from selling all allowances immediately would be the almost the same as the expected net present value of surrendering them steadily throughout the year (discounted at the opportunity cost interest rate that the money could have earned if invested money instead of holding wealth in allowances). The difference would be the result of the buy/sell spread for allowances, which would be expected to be 5% or less. If an individual values the simplification of their life and the saving of time that selling immediately would deliver, then there would be a case for doing so if it was worth more than 5% of the value of the allowances that they were issued with. If an individual were issued with 4 tonnes of allowances and each tonne of these were to be worth £30 in the market, then the 5% loss from selling immediately would only be £6.

There is a benefit to holding on to the allowances, though, for those who are risk averse. For those who sell immediately there is a chance that they may lose out if carbon prices go up significantly over the year, or indeed a chance that they may do well if the carbon price goes down. The chances of these are roughly equal. For a risk averse individual, however, the certain value of carbon allowances (they can always be exchanged for a fixed level of carbon) would be higher than the lottery over future carbon prices. Risk averse individuals would weight the chance of carbon going up in price and their losing money more heavily than the chance of carbon going down in price and their making a profit. How large this benefit would be would depend on the price level for carbon allowances, and the level of risk aversion in the individual. At low prices, risk aversion would not be a strong factor influencing behaviour.

Consider the case of an individual's total allowances having an expected value of £80. Even with quite large percentage variations in their price, the overall

[47] In evidence to the Environmental Audit Committee 2007.

value will not change much in absolute terms. A 30% increase would see their value rise by £24. Individuals could sell the allowances immediately but would run the risk of losing £24 should the market price rise by 30% after this. Should the market price drop, then they would have the chance of making a profit from having sold their allowances when the market price was at a peak. The absolute sizes of these winnings or losses are relatively small to most people. When compared to the hassle factor of engaging fully with the personal carbon trading scheme, they may fail to motivate an individual to fully participate.

Initially, the idea of personal carbon trading may create interest through its novelty, but with familiarity there could be an increasing and progressive disengagement from the which would represent a significant challenge. Some however may find the personal carbon trading scheme a useful tool and continue to participate fully. In order to justify its cost to implement, personal carbon trading would need to deliver emissions reductions not just in the first year but every year.

Irrational trading

Another consideration in relation to personal carbon trading's ability to raise visibility is that in some cases it may drive irrational trading behaviour from individuals. Trading achieves least cost abatement by enabling the least cost abatement opportunities to be exploited no matter how unevenly they are distributed amongst participants. If participants do not trade rationally, however, and undertake abatement themselves at a higher cost than the market price for allowances, then least cost abatement will not be achieved.

A rational approach to trading would include an understanding that the overall level of emissions is set by the cap and that the best way of taking 'responsibility' for ones own level of emissions us to engage in the personal carbon trading market. This is important, as a sense of personal responsibility has been highlighted as a key benefit of personal carbon trading. If what is meant by taking responsibility is to make oneself fully aware of ones energy use, the associated emissions, the climate impact and the cost then there is no conflict with trading. However, if the sense of responsibility means that individuals see their allocation as a limit or target, or a reflection of what a 'fair' level of personal emissions is, then this will prevent trading from achieving least cost abatement, and this will represent an additional cost arising from the implementation of personal carbon trading.

A rational response to a trading system is to compare the cost of allowances with the cost of reducing one's own emissions, taking into account any wider personal benefits there are from undertaking abatement personally. However if individuals associate the allowance with a target, or limit that is imposed on them, or distrust the trading system to deliver emissions reductions, or are intimidated by the trading system, or in some sense value carbon dioxide emissions more highly when they are their own, or distrust future liquidity of the allowance market, or cannot be bothered to ‘optimise’ their behaviour in the trading scheme, then their engagement with the scheme would not be rational.

Not trading rationally implies choosing to undertake abatement even though the market price for allowances is lower than the cost to the individual of abating (or alternatively buying allowances when there would be cheaper ways of reducing ones own emissions). The market price of the allowances reflects the next lowest cost that somebody else is prepared to reduce their emissions for. Which person undertakes the abatement is immaterial for the environmental outcome. Carbon dioxide released by one person causes the same damage as that released by another.

For example: Individual A can only further reduce their emissions by installing micro-generation at a cost of £400 per tonne of carbon dioxide abated. Individual B generally drives to the shops, but if they were paid £20 per tonne of carbon abated this would be sufficient to compensate them for the added hassle of getting the bus. Individual A could pay Individual B to take the bus through the trading scheme, at a cost of £20, and then have £380 to spend on themselves. In such a circumstance the overall level of emissions reductions is the same as the case where the individual installs the micro-generation, but the overall level of welfare is higher.

Irrational responses by individuals to the introduction of the trading scheme would reduce the overall level of welfare in the UK. In so far as it drives individuals to undertake expensive abatement methods which are greater than the cost of abatement through international mechanisms then there will be an overall net loss to the UK. Irrational trading effects will increase the average cost of abatement delivered by the introduction of personal carbon trading and as a result, reduce the net benefit to the UK of its introduction.

Major interactions

This paper identifies over 80 policies that exist, or are planned, which directly or indirectly influence the size of an individual’s personal carbon emissions (Listed in Annex B). These policies have an impact on all the sectors of personal carbon emissions; there is no sector of personal carbon emissions where personal carbon trading would be acting in isolation. This underlines the importance of analysing the strategic fit of personal carbon trading. Which policies co-exist with personal carbon trading will, to an extent, depend upon when it is introduced. This section will consider which major policies will continue to exist in the 2013 or 2020 and the nature of the interaction. It will also consider, where a major policy no longer exists, what impact the policies prior existence will have had on the remaining low cost abatement potential.

In general overlap between personal carbon trading and other policies need not be a cause for concern. Some policies may be complimentary; by working together they may achieve greater reductions in carbon emissions. Others could be made redundant after the introduction of personal carbon trading and so could be retired. However it is necessary to consider the interactions between personal carbon trading and the major policies in greater detail. The overlaps that are considered in this section are between personal carbon trading and:

- The EU Emissions Trading Scheme
- The Supplier Obligation
- The Renewables Obligation
- Transport policy, particularly fuel duty and voluntary agreements with car manufacturers
- Building regulations
- Product Standards for energy using products

Overlap between the EU Emissions Trading Scheme and personal carbon trading

The EU Emissions Trading Scheme (EU ETS) covers approximately 50% of UK CO_2 emissions. It is an international scheme, the UK's commitment to which would continue even should personal carbon trading be introduced. The sectors of the economy that are covered are the most energy intensive ones; power generation and various heavy industries. For these sectors, the creation and trading of allowances for the rights to produce carbon emissions establishes a carbon price. As a result of electricity generators having to surrender allowances to cover the fuel they use generating it, indirectly a carbon price is created for domestic electricity and the emissions associated with domestic electricity use are included in the overall EU cap. Generators pass through the cost of allowances to consumers.

The coverage of the EU ETS will increase in coming years. It is planned to introduce aviation emissions from 2012 onwards. There are discussions concerning the possible inclusion of road transport fuel suppliers and domestic gas and oil suppliers in future phases too. If these latter two were to be included, then the coverage of UK emissions would be almost complete. This section will consider why any overlap between the EU ETS and personal carbon trading matters.

How much of an overlap there is between the EU ETS and personal carbon trading depends on the sectors that are included in the personal carbon trading scheme. The most ambitious proposals for personal carbon trading envisage an economy wide downstream trading scheme for the UK, capturing both personal emissions and emissions from business and other organisations. In which case there would be an overlap for all 50% of UK CO_2 emissions that are included in the EU ETS now, and nearly 60% once aviation is included. Alternative suggestions for personal carbon trading envisage the scheme just covering personal carbon emissions; that is domestic electricity usage, domestic primary fuel use, road transport fuel use, and leisure aviation. This would still create an overlap, with both electricity and aviation being covered in 2012 and the possibility of more overlap by 2020.

The first concern caused by the overlap is that the EU ETS establishes a carbon price in the sectors it covers. One of the avenues for personal carbon trading to add value is through its ability to establish a carbon price. The more that such a carbon price already exists the less that personal carbon trading will add value. The larger the overlap with EU ETS gets and the stronger the carbon price from personal carbon trading, the more significant the issue of the overlap is. In a sector that is covered by both schemes, the carbon price paid by the end user will reflect the sum of the allowance price in the EU ETS and the allowance price in personal carbon trading.

Personal carbon trading will only deliver a financial benefit where it delivers additional abatement that costs less than the cost of international abatement (see Annex A). The cost of allowances in the EU ETS will reflect the cost of one source of international abatement. By overlapping the schemes the combined carbon price will be higher than the cost of international abatement by an amount equal to the cost of personal carbon trading allowances. This will incentivise participants in the personal carbon trading scheme to undertake abatement measures above the cost that will deliver a benefit to the UK. Though personal carbon trading would still deliver additional low cost abatement, some of the additional abatement that is delivered by personal carbon trading will be increasing the cost to the UK of achieving its overall target reductions in emissions.

Trading achieves least cost abatement when flexible. The wider the geographical coverage and the more sectors covered, the more flexible the scheme will be. Personal carbon trading will constrain the EU ETS by driving a certain level of abatement to occur in the UK. For the overlapping sectors, if personal carbon trading is to deliver anything additional, the level of abatement delivered by it will be higher than would have occurred with just the EU ETS alone. Where the personal carbon trading scheme delivers this additional UK abatement not by addressing barriers and unlocking cost effective abatement below the cost of EU allowance prices, but instead by driving relatively high cost abatement, the least cost characteristics of the EU ETS will have been compromised. The loss of flexibility will result in the overall cost of achieving reductions being higher. Furthermore, partially overlapping trading schemes will create inconsistent carbon prices across different fuel types and activities. This will create stronger signals to reduce emissions from some fuel types than others. Overall this will result in inefficient abatement choices being made by individuals, and the cost to the UK overall of achieving its abatement targets will be higher. (For a technical explanation, see Annex D.)

The overlap between a proposed personal carbon trading scheme and the EU ETS creates the question of whether reductions in emissions driven by the personal carbon trading scheme in overlapping sectors will result in actual reductions in carbon emissions or just a redistribution of emissions around the EU ETS. The overall level of emissions, across the EU is established by the cap. How much domestic abatement the UK undertakes in the traded sectors will not affect the overall environmental outcome across the EU, as the cap from phase III onwards will be on a fixed downward trajectory towards the EU emission reduction targets.

Proposals for the overall EU cap on emissions, published on 23 January 2008, have placed the cap on a fixed trajectory towards a 20% reduction by 2020, with an offer to increase this to 30% if a global agreement on climate change mitigation to follow Kyoto is achieved. The cap and its trajectory would not be revised to reflect the success of downstream policies. Reductions in emissions from UK electricity usage, caused by the personal carbon trading scheme, would reduce the number of allowances used by the electricity producers in the UK. As the number of allowances overall in the EU ETS remains constant, this will result in a greater availability of allowances for other participants. Emissions from these would go up, exactly compensating the decrease in emissions from the electricity sector in the UK. The benefit of the personal carbon trading scheme would not be in terms of actual carbon reductions. However, there would be a financial benefit to the UK; the UK would either import fewer or export more allowances.

In the EU ETS, the gap between the national allocation of allowances and the business as usual level of emissions for the UK from covered sectors creates a level of abatement that the UK is responsible for. There are three possible outcomes: the UK exactly matches its domestic abatement to the requirement; the UK has to supplement its domestic abatement by importing further EU allowances; or the UK goes further than the required level of abatement domestically and will be able to export allowances to the rest of Europe.

As the lowest cost abatement options are exhausted and the overall EU cap is reduced the price of EU allowances is expected to increase as the marginal cost of abatement increases. Innovation could counteract this by making available more low cost abatement options. The Shadow Price of Carbon (SPC)[48] is the UK government's estimate of the price of carbon that will be necessary to deliver sufficient abatement to stabilise atmospheric concentrations of greenhouse gases and limit temperature rise to no more than 2 degree Celsius. The price assumes co-ordinated and efficient international action. In the medium term the SPC could be viewed as providing an estimate of the price of EU allowances. This allows a simplified approach of valuing additional domestic emissions reductions delivered by personal carbon trading at the SPC (this would also assume that the net resource cost of the abatement was zero).

In 2013 the EU ETS will exist. In 2020 Phase III of the EU ETS will be drawing to a close, and although it is not certain whether or not a Phase IV will be taking its place, the scheme remains in place unless legislation is taken to remove it. If the EU ETS were not to continue beyond 2020 it is sensible to assume that some other international mechanism would take its place.

The arguments above provide strong reasons not to overlap personal carbon trading with the EU ETS. However double regulation has been justified for the Carbon Reduction Commitment (CRC), where electricity use by participants will

[48] See guidance of the shadow price of carbon, http://www.defra.gov.uk/Environment/climatechange/research/carboncost/index.htm

be covered by both the CRC and the EU ETS. In this case the justification for the double regulation was that there were significant unexploited low cost abatement opportunities that were being neglected by business, the barriers to which would not be addressed by the price signal from the EU ETS. By overlapping the CRC, the visibility of electricity use will be raised for participants and it is hoped that this will result in greater exploitation of the abatement opportunities. A similar argument could be developed for personal carbon trading. It would be necessary to argue that the visibility generated by personal carbon trading would unlock significant abatement costing less than the SPC in the traded sectors.

Interaction with the Supplier Obligation

Theoretically the Supplier Obligation, planned to start in 2011 could be retired upon the introduction of personal carbon trading, however this is unlikely to be the case for the following reasons:

- The Energy Review (2006) and The Energy White Paper (2007) underlined the government's commitment to retain an energy efficiency commitment type of policy until 2020, with a similar level of activity to CERT. CERT is projected to produce 4.2 $MtCO_2$ of savings by end of programme (runs 2008-11 inclusive)
- The EU directive on Energy end-use efficiency and energy services requires of governments to achieve an overall national indicative energy savings target of 9% between 2008 and 2017 by means of energy services and other energy efficiency improvement measures. It also requires that energy suppliers should offer either competitively priced energy audits and/or energy efficiency improvement measures or move to an energy services model.
- In evaluations of the effectiveness of the EEC policies, they have proved to be extremely cost effective[49]. The "Evaluation of the energy efficiency commitment 2002-5" by Dr Eoin Lees states:

"In summary, during the EEC1 period, energy suppliers have more than met their legal target requirements. Stimulated by energy suppliers, some £600 million has been directly invested in energy efficiency. This investment has delivered net present value benefit to householders of £3.1 billion and has saved electricity with a national cost effectiveness of 1.0p/kWh (or 1.3p/kWh if the Defra estimate of the heat replacement effect is included) and for gas at 0.5p/kWh - these are significantly less than the consumer prices of these fuels. For every £1 spent by the energy suppliers, householders have benefited by £9."

Given these reasons, it is assumed that the supplier obligation will exist alongside any personal carbon trading that is introduced prior to 2020.

[49] http://www.defra.gov.uk/environment/climatechange/uk/household/eec/pdf/eec-evaluation.pdf

As discussed in the section on what policies need to deliver (p15), the majority of cost effective technological abatement measures will be delivered by existing policies. For domestic measures, a large proportion of these will be delivered by the succession of obligations that have been placed on suppliers to deliver energy efficiency measures. EEC, EEC2, CERT and from 2011 the Supplier Obligation will nearly exhaust the low hanging fruit for technological abatement in homes by 2020. Projections for the remaining potential in 2020 can be found in the BRE report “Delivering cost effective carbon savings measures to homes”. At present there are no predictions that innovation will deliver new measures costing less than the SPC[50]. The technological potential that has not been delivered by 2020 is unlikely to be unlocked by the introduction of a personal carbon trading scheme. The barriers that are preventing the uptake of these cost-effective measures are not financial but instead a mixture of ‘hidden costs’ in the form of hassle to have them installed or ongoing costs, ‘split-incentives’ and a failure to nurture innovation. The raised visibility of personal carbon emissions and the carbon price established through a personal carbon trading scheme would have a limited impact on these barriers.

The supplier obligation is projected to deliver significant levels of abatement, 1.1–1.5 $MtCO_2$ per year that it is in operation as compared to the previous year. If the policy is successful in delivering this, it will have prescribed where a significant proportion of personal carbon emissions abatement will come from. The existence of policies that make such decisions reduces the flexibility of trading schemes; with constraints on their flexibility they lose their theoretical ability to deliver least cost abatement. Combined with building regulations, and product policy (see later sections) residential emissions are projected to have reduced to 99 $MtCO_2$ in 2020 in comparison to their 1990 level of 147.8 - a reduction of 33%. These are significant reductions that are already being delivered by existing policies. Personal carbon trading would have to deliver reductions beyond this level, or reduce the cost of these reductions being achieved, to add value.

Personal carbon trading could add value through behavioural change brought about by the increased visibility of personal carbon emissions. Behavioural change in terms of individuals choosing to install low cost technological measures will be limited for reasons described above. However, through raising awareness of personal responsibility for emissions and the connection to personal energy use, visibility could result in a lower demand for energy services. This potential route for personal carbon trading to add value may be reduced by the existence of the post-2011 Supplier Obligation which the government hopes will reward suppliers for reducing the overall demand for energy from their customers.

Suppliers previously hit their energy efficiency commitment targets by encouraging individuals to install technological measures such as energy efficient light bulbs or loft insulation but suffered no penalty if customers responded by increasing the number of light fittings they had in their home or increasing the internal temperature of the home. The Supplier Obligation is

[50] For instance, see ‘Generating the Future’ by the Energy Saving Trust, which provides cost estimates for micro-generation technologies in 2020 and 2050.

intended to move away from such a measures based approach, to a hybrid policy that in some way rewards outcomes in terms of overall reductions in delivered energy. Should this change be successful, suppliers would end up offering incentives for customers to change their behaviours as well as to install technological measures. Rewards to customers for reducing their overall energy use will potentially drive some of the behavioural changes that could have been delivered by personal carbon trading. Where suppliers successfully manage to pick the low hanging behavioural fruit, the additional value of personal carbon trading will be lower. An accounting difficulty would exist in attributing the carbon savings between personal carbon trading and the Supplier Obligation.

Amongst the hybrid design options that are being considered for the Supplier Obligation, some would create a carbon price for domestic primary fuel. For instance, if the final proposal includes a cap and trade scheme covering UK suppliers of domestic primary fuel, the pass through of allowance costs would result in an increased cost to consumers; a carbon price. A situation where a further carbon price is delivered by personal carbon trading would create the potential for an inappropriately high carbon price for domestic fuel as it would be equal to the sum of the carbon price from both schemes.

Overlapping cap and trade would also create an issue as to which were delivering a benefit. Should the personal carbon trading cap be stringent enough to deliver a greater reduction of domestic primary fuel use than required by the Supplier Obligation cap and trade, then the latter would deliver no benefit and would just create an additional regulation cost. Should the Supplier Obligation cap deliver a greater reduction in primary fuel use than would have been generated from personal carbon trading, then the additional reduction will result in some non-least cost abatement being delivered. Additional personal carbon trading allowances would be made available for other personal carbon trading sectors. The overall level of emissions would remain the same in the personal carbon trading scheme, but the overall cost of achieving it would have increased.

If personal carbon trading is introduced in 2013 then it will co-exist with the Supplier Obligation. Any behavioural changes that are delivered by the Supplier Obligation will reduce the added effectiveness of personal carbon trading. Should the Supplier Obligation introduce a cap and trade scheme, then this will significantly compromise the benefit of personal carbon trading in the domestic sector, both from the interaction of having two overlapping trading schemes, and due to a carbon price already existing. If personal carbon trading is introduced later in 2020, then there may not be a Supplier Obligation or similar policy. As a result personal carbon trading could deliver additional value through the creation of a carbon price, and would not suffer a negative interaction with an existing cap and trade scheme. However the issue of low cost technological abatement options having been exhausted by a further decade of obligations on suppliers to deliver energy efficiency measures to households would still arise. This would largely limit the potential of personal carbon trading to deliver value in the domestic sector to creating behavioural change that reduced demand for energy services.

Interactions with the Renewables Obligation

The Renewables Obligation (RO) requires suppliers to generate a certain proportion of their electricity from renewable sources, or pay a 'buy out' price. The funds collected from this buy out price are proportionally distributed between those that have generated renewable electricity. This policy would interact with personal carbon trading in the following ways:

- The Obligation reduces the flexibility of a personal carbon trading scheme;
- It would reduce the carbon intensity of domestic electricity, reducing the level of carbon emissions an individual would be responsible for;
- Personal carbon trading would provide an additional incentive for micro-generation.

In an alternative future with no RO but with personal carbon trading, electricity bills could detail not only the number of units of electricity that have been consumed, but the carbon density of the supply. This carbon density would relate not to an average grid emissions factor but relate to the particular supplier, dependent on the portfolio of power generation that had been used to supply the electricity. When purchasing electricity an individual would have to surrender a number of allowances that is equal to the quantity of electricity consumed multiplied by the carbon density of the electricity. This opens up the possibility that electricity suppliers could compete not only on the price of their electricity but the associated emissions factor.

A power company that had a larger proportion of efficient or renewable energy generation would have a lower emissions factor, buying electricity from them would reduce the number of allowances an individual would have to surrender, making it more attractive. With no RO this could drive investment in renewable generation as the market price for carbon allowances would place a value on clean electricity. With a fully flexible trading system, the cost of saving carbon from electricity generation would be compared with other methods of reducing personal carbon emissions, so achieving an efficient reduction in emissions. However, with the RO in place, the emissions factor for different suppliers is to an extent harmonised, as all suppliers are the same percentage target. For example in 2008 the target is 7.9% of electricity supplied to be sourced from renewables. Therefore, the level of investment in renewable electricity is driven by the Obligation and not by the efficient trading mechanism. The potential added value of personal carbon trading should not include the possibility of significantly driving the de-carbonisation of the electricity supply.

The level of renewable electricity in the UK is set to increase significantly between now and 2020; current Government expectations are the UK will reach 15% renewable electricity by 2015. If this is achieved it will reduce the average level of emissions associated with electricity use, and will therefore reduce the level of emissions that individuals are responsible for. This will progressively reduce the coverage of the personal carbon trading scheme.

Another issue raised is that the Renewables Obligation provides an incentive for individuals to install micro-generation plant. In the proposals for the reformed RO, micro-generation will receive two Renewable Obligation Certificates for each megawatt hour of electricity produced. With a personal carbon trading scheme in place, there would be an additional incentive, as any energy produced through micro-generation would displace grid electricity/fuel that would have required personal carbon trading allowances to be surrendered. The question is raised whether the combined incentive may over-incentivise micro-generation technology. (There are other incentives for micro-generation too: Reduced VAT on micro-generation plant, sale of ROCs is income tax free and grant programmes for installation.)

This illustrates how there may be a requirement, in the specific area of micro-generation, to reconsider the balance of incentive policies that are offered should a personal carbon trading scheme be implemented. More generally there may be a requirement to reconsider the balance of incentives for other abatement measures. As another example, if personal carbon trading shortens the pay back time for installing insulation this may create a question over the continuation of the policy to offer reduced VAT on insulation materials.

Interaction with road transport policy

Transport policy will interact with personal carbon trading in four critical areas:

- Fuel Duty and revenue
- EU voluntary agreements with car manufacturers – no benefit to driving choice of efficient vehicles in terms of overall average emissions of EU fleet.
- Electricity as a road transport fuel.
- The Fuel Quality directive.

Fuel Duty was introduced in 1909 and is unlikely to be retired upon the introduction of a personal carbon trading scheme. It is justified both for the revenue it raises and in terms of the economic ‘bads’ that are associated with personal car use. Carbon emissions are not the only ‘bad’; there are also social costs to personal transport in terms of congestion, landscape impact, air quality and so on. If personal carbon trading were to be introduced, it could create demands for a reduction in fuel duty, with implications for the revenue of the Treasury. Drivers could feel that they had already paid their carbon price through the use of their personal carbon trading allowances and so resent the imposition of an additional fuel duty, part of which could be seen as a carbon price.

As the price of carbon allowances go up, there may be increased calls for a compensatory reduction in fuel duty. Were such a compensatory reduction granted, even if only partially, then the additional financial signal from personal carbon trading encouraging individuals to reduce their use of personal car transport, would be muted. If a ceiling price for personal carbon allowances was set at the shadow price of carbon (see discussion on ceiling prices on p3), which is £29/t CO_2 in 2013, then the maximum increase in price possible for a litre of fuel, achieved through personal carbon trading, would be 7.25p in 2007 money. This price signal is already weak in comparison to the existing cost of a litre of fuel, creating an approximate 7% increase in price. Were the fuel duty to be reduced at all, then this percentage increase in costs would be even smaller.

The EU voluntary agreements with car manufacturers will be succeeded with mandatory targets for manufacturers to improve the average efficiency of vehicles sold. The present agreement requires the average emissions of vehicles sold to reach 140g/km or lower by 2008/9. Recent proposals for the successor policy have stated a target average of 130g/km by 2012 from fuel efficiency alone. There is a proposed penalty of €95/g/km/car for failure to achieve the target. These requirements are likely to improve the efficiency of cars that are bought in the UK. Manufacturers, motivated by the wish to avoid the penalties, would be expected to make efficiency improvements across their range, as well as adjusting price differentials and their advertising focus.

The introduction of a personal carbon trading scheme could drive consumers to purchase even more fuel efficient vehicles in the UK than if the EU agreement was acting alone. Personal carbon trading could encourage individuals to purchase even smaller cars and vehicles that are ‘best in class’. As far as personal carbon trading encouraged an additional shift to more efficient vehicles, the level of emissions in the UK would be reduced. However as a result of the average requirements on fuel efficiency that apply to manufacturers, this may have a limited impact on emissions from vehicles within the EU.

A manufacturer that is required to achieve an average efficiency level would be able to sell larger and less efficient vehicles in the rest of Europe as a result of selling more efficient vehicles in the UK, without incurring a penalty. Although road transport fuel is outside of the EU ETS, a reduction in emissions in the UK due to individuals choosing more efficient vehicles would result in a compensatory increase in emissions elsewhere in Europe. The overall efficiency of cars sold in the EU will be set by the mandatory efficiency cap.

This can be illustrated with an example. Say the UK represents one sixth of new car sales in the EU for a particular manufacturer. Before the introduction of personal carbon trading, the average efficiency of vehicles sold in the UK by this manufacturer is 130g/km. The manufacturer must therefore achieve an average efficiency of 130g/km, from its sales in the wider EU, to avoid a penalty. Personal carbon trading is now introduced, and UK consumers respond by buying more efficient cars. The manufacturer continues to sell one sixth of its overall EU sales in the UK. Now the average efficiency of vehicles sold by the manufacturer in the UK is 100g/km. As a result, the manufacturer could sell cars with an average efficiency of 136g/km in the wider EU and still avoid a penalty. To the extent that the manufacturer took advantage of this, there would be a compensatory increase in emissions in the wider EU.

Introducing personal carbon trading might affect the growing popularity of electricity as a road transport fuel. Electric cars are more efficient than cars with combustion engines. Should the electricity supply be progressively de-carbonised, then electric cars will become increasingly low carbon vehicles. There are other benefits to electric cars too, such as lower air pollution in towns and cities as a result of the associated emissions being released in power stations and not by the car in urban areas. For these reasons it would not be desirable for personal carbon trading to prevent the development of the electric car industry. Were electricity to be included within a personal carbon trading scheme, however, electricity as a road transport fuel would be relatively disadvantaged. The double regulation (emissions covered both in the EU ETS and personal carbon trading) would result in a higher carbon price for electricity. This would create a perverse effect where the introduction of personal carbon trading might create a barrier to the adoption of a relatively carbon efficient technology.

The response to this, and other difficulties raised by the inclusion of electricity in personal carbon trading could be not to include personal electricity use within the personal carbon trading scheme. This however causes another difficulty. If personal carbon trading were not to include electricity, it would no longer be the case that all emissions associated with personal car use would be included in personal carbon trading. The coverage of personal transport emissions would shrink over time should electric vehicles become more popular. This would limit the added value of personal carbon trading scheme going forward.

Finally, the EU is currently in the process of finalising a new fuel quality directive which will require lifecycle emissions savings from road transport fuel of 10% between 2011 and 2020. Around 80-85% of the emissions associated with the fuel are created when the fuel is combusted in the vehicle, the remaining percentage resulting from the oil rigs, pumping, refining and transport of the fuel. These upstream emissions can be reduced by greater efficiencies at refineries and in the process of removing the oil from the ground. For the emissions associated with the combustion, they can be reduced by blending of the fuel with bio-fuels. This will result in the emissions from a given use of personal transport being reduced, prescribing where some personal emissions abatement will come from.

Interaction with building regulations and product standards

Building regulations are projected to make a significant contribution to UK emissions reductions. Existing standards are projected to contribute 12.1 $MtCO_2$ per annum by 2020, with additional savings of 4.1 $MtCO_2$ per annum if the ‘building a greener future’ proposals for future tightening of the regulations are adopted. By 2050, it is estimated that approximately 30% of the housing stock will have been built under these new regulations.

Building regulations, including sections on the energy efficiency of buildings, would continue to exist alongside any personal carbon trading scheme. This is because there are market failures and barriers to energy efficiency that would not be wholly addressed by a personal carbon trading scheme. Short tenure for householders, creates either an artificially short payback horizon for energy efficiency measures, or requires that the value of the future savings created by the investment can be realised in the price that a home is sold for. For landlords, unless the investment results in a higher rent then none of the benefits of the energy efficiency investments will accrue to them. These issues are being at least partially addressed by policies attempting to increase the availability of information and awareness about the energy efficiency of properties – energy performance certificates and the carbon calculator for instance. However tenure still creates a barrier to socially optimal investment in energy efficiency and this applies to new buildings too, where the tenure of the developer is particularly short. Bounded rationality[51] plays a role too, with individuals using high discount rates when considering the future benefits of energy efficiency investments. Building regulations provide a cost-effective way to address these market failures, delivering close to the socially optimal level of investment in energy efficiency measures in new buildings.

Building regulations have been tightened in all of England, Wales, Scotland and Northern Ireland over recent years. The regulations require target levels of energy efficiency for buildings. The government has released a policy proposal whereby new building regulations would be further tightened in 2010, 2013 and 2016 in England and Wales. The aspiration is for new buildings to reach zero carbon standards in 2016. From 2006 some repair and renovation work to existing housing stock also falls under the building regulations. Where the work renovates a thermal element (any part of an external wall, roof or ground) and is performed on more than 25% of it, then minimum energy efficiency standards must be achieved. The regulations also require replacement boilers to be condensing boilers which are the most efficient boilers available and for replacement double glazing to be of a minimum standard.

For those purchasing new houses there will be no possibility for them to cost-effectively reduce their carbon emissions using technological measures relating to the fabric of their homes. The zero carbon building standards will have mandated builders to go beyond the existing cost-effective measures in order to comply. The justification for doing so is that this would drive innovation, particularly in micro-generation technologies. For those undertaking renovations, the regulations prescribe minimum standards that will deliver all cost-effective abatement measures. These regulations will limit the additional technological abatement that could be delivered by personal carbon trading. The regulations will have made the choices. These not only limit the potential for personal carbon trading to add value, but also, were a personal carbon trading scheme to be introduced; they would limit the flexibility of the trading scheme as a significant proportion of the carbon reductions required within the personal carbon trading scheme would be achieved through the building regulations.

On the 11th of August 2007 the EU directive on the Eco-design for energy using products was transposed to the UK. This directive provides a framework within which not only the energy efficiency of products during use is regulated, but

[51] People show 'bounded rationality' when they are only partly rational but in other aspects of their behaviour they show emotional or irrational behaviour.

also standards for the sustainability of manufacture and disposal of energy using products. Existing product standards that covered efficiency of boilers, fridges, freezers and fluorescent lamp ballasts will be incorporated into and updated through implementing instruments within this framework. Work in ongoing within the EU and the UK to issue further implementing instruments that will cover all other major categories of energy using products. These will be enacted over the next few years and will certainly be in place by 2013.

These regulations will possibly be used going forward to edit consumer choice. In a world without such editing, personal carbon trading could have driven consumers to choose A++ rated appliances rather than the G rated appliances they might otherwise have bought. However, with the eco-design directive and other regulations, consumers will only have a choice of relatively efficient appliances; the additional impetus from personal carbon trading to purchase efficient appliances will only have a marginal impact, perhaps encouraging the purchase of A++ rated appliances instead of A rated. The additional value of personal carbon trading will therefore once again be limited in terms of the technological measures that it would encourage.

In addition to the product standards, an agreement between retailers, manufacturers and government has been reached to ban the sale of incandescent light bulbs in the UK from 2011. This will once more limit the potential for personal carbon trading to add value and constrain the flexibility of a personal carbon trading scheme. These regulations, both building and product, will co-exist with personal carbon trading both in 2013 and in 2020.

5 Assessing the costs of Personal Carbon Trading

So far we have assessed the potential benefit of personal carbon trading in terms of its effectiveness and what the benefits of it might be. This section will consider the costs that implementing a personal carbon trading scheme would create. These costs can be divided into three different categories:

- Costs of implementing, administering and enforcing the scheme
- The cost of people's time in engaging with the scheme
- Costs of any unintended consequences created by the scheme

Costs of implementing and administering the scheme

A separate study into the technical feasibility and cost of implementing personal carbon trading has been carried out in parallel to this report, which provides more detail. In order to assess the economic efficiency of personal carbon trading we must describe the main factors that will contribute to the costs associated with the implementation of such a scheme.

A database would be required to hold details of all those who were eligible for allowances. There is currently no existing database that could fulfil this function, though there is the possibility that some cost savings could be made through the adaptation of an existing Government database (e.g. benefits system). However the database is established, there would be additional ongoing maintenance costs in keeping the data up to date. For instance, changes of details would be required for people reaching the age of entitlement, marrying, leaving the country, re-entering the country, or dying.

In addition to the database, the scheme would require the allowances to be distributed. If carbon cards are to be issued then the printing of these and their distribution would carry a further cost. Lost and stolen cards would add a further administrative burden. The scheme would also require a payment infrastructure; a secure and efficient way of transferring allowances between consumer and retailer, but also between individuals. For the trading scheme to work efficiently, a secondary market in allowances would be required. This would require the creation of a trading platform. If an economy wide scheme were to be implemented it would require an auctioning mechanism through which the government would sell the allowances.

Finally, the scheme would require enforcement expenditure. A downstream scheme with 50 million participants presents a difficult challenge. This is particularly true for fuels for which the supply chain is less well know and controlled. For example, coal has a diffuse and relatively informal supply chain that could present a potential problem. Auditing, monitoring and investigations will be required to maintain the integrity of the scheme, all of which will carry costs.

In summary, there are a number of factors that will add to the costs of implementing and running a personal carbon trading scheme. For all factors there is likely to be an up front expenditure to establish the systems and processes that are required and then a significant ongoing annual cost for maintaining them.

Costs of people's time

With a carbon tax, or an upstream trading scheme, there would be no additional cost in terms of individuals' time. The cost of energy would be increased but paying for items would involve no additional transactions, and there would be no requirement for individuals to register, maintain a separate carbon account or make trading decisions. A personal carbon trading scheme will add complication to individuals' lives and take up their time; these are costs which must be included in the assessment of personal carbon trading.

It cannot be stated with any certainty how much of an individual's time would be taken up with personal carbon trading. Initially there would be a requirement for individuals to familiarise themselves with the scheme and to register, resulting in an additional initial time burden. Over time the scheme would require less time and effort. What can be said however is that with around 50 million participants the total quantity of time will be significant. Even if the scheme only uses up four hours of each individuals time per year on average, that will create a cost of 200 million hours of time.

It is not simple to apply a value to this lost leisure time. For instance, some of the time spent on the scheme may be rewarding. However, the mandatory nature of the scheme makes the time cost an imposed burden and a significant proportion of the time taken up will be bureaucratic and repetitive. The Department for Transport places a value on non-working time for its cost-benefit analyses, which in 2007 is £4.94[52]. If this value were used to assess the cost of the time burden for individuals of a personal carbon trading scheme then on the assumption of 200 million hours used up, it would add around £1billion pounds per year to the costs of a personal carbon trading scheme. This figure represents only a rough estimate, but is included to underline that the costs associated with the time burden would be non-negligible for a personal carbon trading scheme. For the sensitivity analysis a range of £0.5billion to £1.5billion is used.

Costs of unintended consequences

The introduction of personal carbon trading would create a number of unintended consequences. Such consequences would carry costs, either in terms of increased carbon emissions or financial costs to the UK, or both. They can arise due to 'boundary effects'; where the countries surrounding the UK do

[52] http://www.webtag.org.uk/webdocuments/3_Expert/5_Economy_Objective/3.5.6.htm#012

not adopt a personal carbon trading scheme so creating an incentive for individuals to undertake their carbon intensive activities abroad. The rebound effect will also raise questions for the added value of personal carbon trading; the scheme will encourage individuals to substitute their consumption away from the covered energy and flights but they may substitute to other activities that result in carbon emissions. Finally where enforcement fails, and informal markets for fuels develop (such as coal), perverse incentives for individuals to substitute to dirtier fuels may arise.

For an individual considering flying to Australia, after the introduction of personal carbon trading they may face a considerable cost in terms of the number of additional carbon allowances that they would have to purchase if they fly from the UK. If instead of purchasing a direct flight from the UK to Australia they choose to purchase a flight from the UK to Paris and then from Paris to Australia, they would only have to purchase allowances to cover the flight from the UK to Paris. The saving in terms of allowances may be sufficient to make the hassle of an indirect flight worthwhile. The two stop flight will be responsible for more emissions than a direct flight, because of the extra emissions associated with take-off and landing as well as increasing the overall distance flown. The introduction of personal carbon trading will therefore have created a perverse incentive for individuals to increase their level of pollution.

This is an example of a 'boundary effect', other examples would include choosing to fill up with petrol abroad, or bringing a trailer load of coal back from a holiday in France. Such boundary effects would also be present for other policies that increased the cost associated with personal carbon emissions in the UK to a higher level than they are elsewhere, such as a carbon tax. As a result when comparing personal carbon trading to other policy options, only additional unintended consequences should be considered. As the incentives are likely to be broadly similar with a carbon tax, upstream trading or personal carbon trading these additional effects are likely to be limited.

The term 'rebound effect' is generally used to refer to the phenomenon of improvements in energy efficiency resulting in an increased demand for energy. The result is that the overall reduction in energy use is less than would be anticipated from the improvement in the technology. An example helps to illustrate. Consider improvements in the energy efficiency of light bulbs, the result is that the cost of the energy service 'light' is reduced. As the cost of light has gone down, individuals may choose to light more spaces, and light spaces more brightly. The result is that although the amount of energy required for a given amount of light has gone down, the demand for light has gone up, offsetting the benefit of the energy efficiency improvement. The reduction in the cost of lighting has reduced the expenditure required to maintain a given lifestyle, the surplus resources the individual has left are then re-allocated to other activities, some of which may require energy.

The analogy with personal carbon trading is that the effect occurs but for the reverse reason. The increase in the cost of activities covered by personal carbon trading makes these energy services more expensive. The individual chooses to substitute away from them and with a given level of resources reallocates some of their expenditure. Where the expenditure is re-allocated to sectors that are not covered by personal carbon trading this will result in an increase in carbon emissions that will to some extent offset the reduction from the substitution away from the original activity. For example, consider an individual who reduces their use of gas by turning their thermostat down. They will have additional resources to spend elsewhere which if they spend it on air freighted vegetables will result in increased emissions elsewhere which counteract the saving from the reduction in domestic gas use.

Enforcement is more difficult with a downstream scheme, where diffuse transactions must be monitored. Where enforcement fails, and informal markets for fuels exist outside of the personal carbon trading scheme perverse outcomes may result. Those fuels that are not covered will not carry the additional cost of personal carbon allowances and will therefore become relatively cheaper. For certain fuels the supply chain is well understood, known and controlled; petrol, diesel, electricity, on grid gas. For others however the supply chain is more informal, most notably coal and coke. These fuels would be the most likely to be traded outside of the scheme, and so become relatively cheaper. This would have a perverse impact given that they are amongst the dirtiest fuels that individuals could use. Personal carbon trading could have a perverse impact of increasing consumption of these informally traded dirtier fuels.

6 Relative merits of upstream and downstream trading

Description of upstream and downstream trading

Cap and trade schemes are designed to create a fixed limit on the level of emissions within the sectors they cover, while allowing flexibility as to who emits what. Allowances, equal in quantity to the target level of emissions are created and then distributed to agents within the covered sectors of the economy; the number of allowances establishes the cap, or limit on emissions. The method of distribution could vary from auctioning to free allocation. Through the trading of allowances the system enables the least cost abatement methods to be exploited, wherever they are located and however unevenly they are distributed between agents.

How far upstream or downstream a system is, depends on which agents in the economy are required to purchase or surrender allowances to match the carbon associated with their activities. A system that is as far upstream as possible will focus on agents who are as close to the source of fossil fuels in the economy as possible. This would include producers of fossil fuels as well as those agents that import them. A downstream system will focus on agents who actually combust fossil fuels, be they companies using fuels in their industrial processes, or individuals using fuel to heat their home. An ultra-downstream system would focus on agents' responsibility not just for direct emissions from the use of fossil fuels, but also their responsibility for indirect emissions. Examples of this would be requiring agents to surrender allowances for the purchase of airline tickets, electricity or the emissions associated with the production of their meal.

The EU ETS is an example of a cap and trade scheme. At present it is a downstream scheme that includes only energy intensive sectors of the economy. Firms covered by the EU ETS are required to report their use of primary energy and then, during the reconciliation process, provide allowances to cover the associated level of emissions. However there are proposals for the future inclusion of less energy intensive sectors of the economy that will be addressed at a more upstream level. For instance suppliers of gas or home heating oil, and suppliers of road transport fuel may be included in future phases. These agents do not use the fuel themselves, they are upstream of its use, but would be required to surrender allowances equal to the level of emissions associated with the fuel that they supply. The extra costs associated with complying with the EU ETS requirements, would result in a price signal to those buying primary fuel from them. This coverage of suppliers could be termed 'mid-stream' as it is not as far upstream as it is possible to get. A cap and trade system that focussed only on agents that imported or produced fossil fuels would be further upstream still. Trading systems could function while adopting a hybrid approach to the level at which they focus, choosing the level that is most appropriate for the sector under consideration.

Administering a sector at a downstream level will greatly increase the number of agents that the system covers, particularly for sectors that cover individuals' use of energy. Administering the electricity generation sector at a downstream level may require compliance by a few hundred sites, but administering domestic primary fuel use at a downstream level could involve administering approximately 50 million agents. At the other extreme, an upstream system that focussed solely on the producers and importers of fossil fuels would have to administer only a relatively limited number of agents within the economy, a few hundred to cover all sectors of the economy. An economy wide downstream system, on the other hand, would need to administer all individuals in the economy as well as all business entities and other organisations within the economy; perhaps 60 million agents.

One of the attractions of personal carbon trading is that through an equal allocation of allowances it is perceived to be fair[53]. Those that produce a lot of carbon emissions are required to buy additional allowances from those that produce fewer. In this way those that live a low carbon lifestyle are rewarded through the opportunity to sell their unused allowances. This reward for low carbon living is key to the perceived fairness of personal carbon trading. However it is wrong to think that *only* personal carbon trading would have the effect of rewarding low carbon living. Both carbon taxes and upstream trading, where the revenue is recycled on an equal per capita basis, could result in those with low carbon lifestyles receiving an overall financial benefit from the scheme. The reward is less visible however compared to explicitly receiving money for surplus carbon allowances.

It should also be noted that the overall equity impact of a personal carbon trading scheme would depend not only on the redistribution of money through the allocation and trading of allowances, but also on how the costs of implementing a personal carbon trading scheme were funded. On average low income individuals may profit from selling surplus allowances, but this effect would be negated should they find themselves paying an additional £30 per year through indirect taxation to fund the scheme. No assumption has been made in this report about how the additional costs of implementing personal carbon trading would be met, however strong statements about the equity impacts of personal carbon trading cannot be made without a consideration of the overall costs of the scheme.

In an upstream trading scheme, allowances could be auctioned to the fuel producers and importers that are covered by the scheme. This would raise revenue for the government and result in an increase in the price of goods and services in line with their carbon content. The revenue from the auction could be recycled to individuals in a similar way as personal carbon allowances are distributed. This could take the form of an explicit carbon bonus paid out by the government to individuals, or through the reduction of other taxes and increases in benefits. The latter method would be less accurately equal, but would not involve the additional administration required for a carbon bonus. It would be possible to distribute the money on either an equal per capita basis, or in a more progressive fashion.

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[53] Starkey explores the 'fairness' of equal allocation in "Allocating emissions rights: Are equal shares, fair shares?", forthcoming.

In such a scheme, those that lived low carbon lifestyles would be rewarded in the same way as in a personal carbon trading scheme. They would contribute less to the tax, as they use less carbon, but would benefit from a roughly equal share of the recycled tax revenue. This would be either through the explicit bonus, or through paying less on other taxes or gaining more from benefits they claim. As a result of this, the 'fairness' of personal carbon trading should not be seen as a unique attribute. Indeed, due to the smaller funding requirements for implementing an upstream scheme, there would be lower indirect costs for individuals, which could result in a relatively more progressive impact overall.

Theoretical equivalence of outcomes with upstream and downstream trading

Under perfect market conditions an upstream trading scheme delivers the same outcomes as a downstream scheme. The price signal created through trading will be identical in both schemes, which if agents are rational will result in the same abatement choices being taken. The mechanisms through which the two systems achieve their reductions are now described in turn.

In the downstream scheme the limited number of allowances will result in their having a value in the market place. Any individual who can reduce their level of emissions through an abatement opportunity (be it installing a technological measure, or reducing their demand for energy services) more cheaply than this market price will find that it is a net benefit for them to take this opportunity. The cost of continuing to emit would be the cost of having either to buy an allowance on the market or, in the case where they hold an allowance, foregoing the opportunity to sell their allowance on the market (which would have earned them a sum equal to the market price). A benefit with a lower value than the market price would therefore not justify the cost. The market price will settle at a price where enough participants undertake abatement opportunities which carry a net benefit for the emissions to stay within the cap.

In an upstream scheme producers or importers will have to pay this extra cost when undertaking activities that release fossil fuels into the wider economy. This cost will be the result of having to purchase additional allowances, or in the case that they were given an allocation, the foregone opportunity to sell some of their allowances. The increase in costs will result in companies seeking to pass on the costs of the additional allowances to customers. Under perfect market conditions, 100% of the allowance cost will be passed through to customers. This price signal will then be transmitted through the supply chain until the final end user of the fossil fuel will be confronted with an increased price for fossil fuels. For emissions to remain within the cap, this price signal must drive consumers of fossil fuels to reduce their demand. As in the downstream system, those who derive the least benefit from the use of fossil fuels (and therefore have the lowest cost associated with reducing their level of use) will be the first to abate. The extra cost associated with their use will outweigh the benefit and the individual's overall welfare will be increased by choosing to abate.

Under the strong assumption of perfect market conditions, the price rise needed in the upstream system to drive individuals to reduce their use of fossil fuels would be the same as the market price of permits in the downstream system. Individuals will face the same costs associated with abatement options, and as a result the same least cost options would be exploited in both cases. For the consumer of energy, the financial incentives are identical under both systems and the resulting changes in use of technology and demand for energy services are therefore also identical. In both systems the price for allowances would fluctuate unpredictably in the market place, creating an element of uncertainty for those considering investments in abatement technology.

In practice, barriers exist to energy efficiency and emissions abatement. If upstream trading has a different impact on these barriers compared to downstream trading, then the outcomes that they produce will no longer be equivalent.

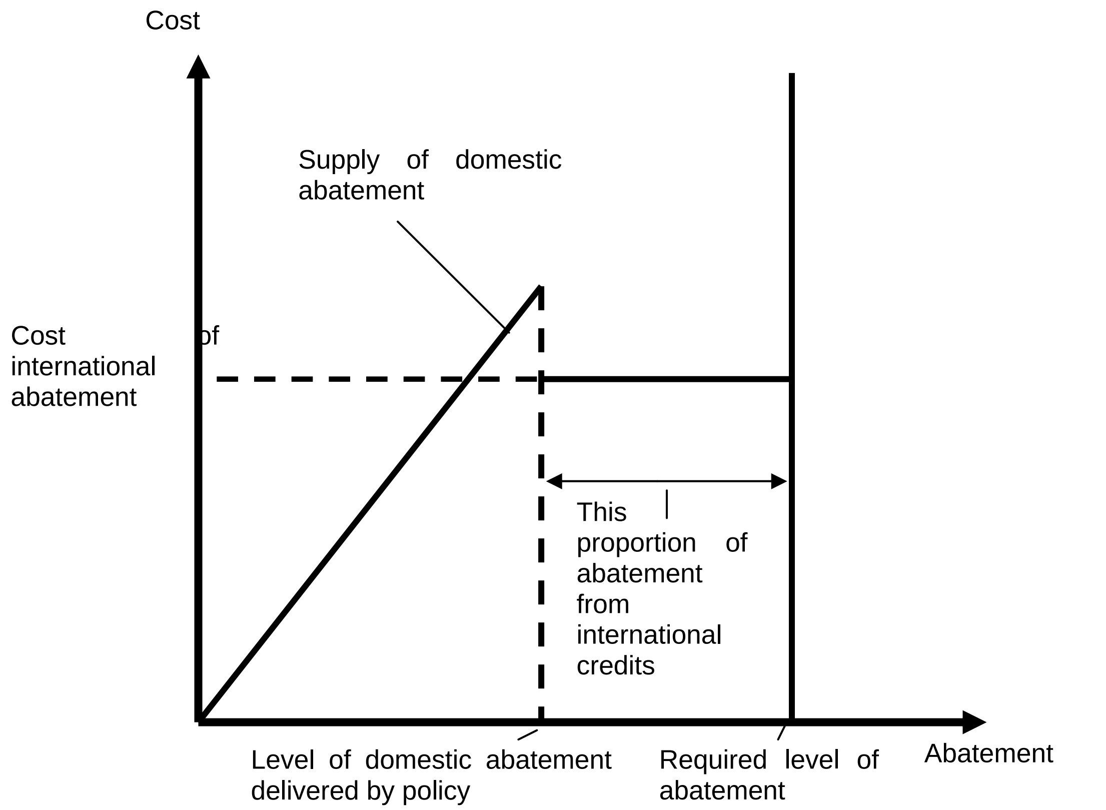
It has already been discussed that personal carbon trading would act on two barriers: by creating a carbon price and increasing awareness of personal carbon emission through raising visibility. An upstream trading scheme would create a carbon price, but would not deliver the additional visibility benefit. The key difference between the two schemes would be what impact this additional visibility would have. Without the differential impact of the visibility created by personal carbon trading, the price of allowances in an upstream trading scheme and a downstream trading scheme, with identical overall caps on emissions, would be the same. If the visibility delivers additional abatement, then the allowance price in personal carbon trading will decrease.

Personal carbon trading, if it were to address the barriers to efficient overall abatement more effectively, would result in a lower expenditure on abatement to achieve the targeted emissions reductions. If this reduction in expenditure was large enough it would offset the additional cost of running the scheme in comparison to implementing an upstream trading scheme. The result would be that the net cost to the UK of achieving its emissions reductions would be lower. **The case for introducing a downstream scheme relies on it driving a large enough additional up-take of cost-effective abatement measures that would have not been delivered by upstream trading.**

The value of the relative benefit from personal carbon trading depends on whether there is flexibility about whether the Climate Change Bill target reductions are achieved through both domestic abatement and international credits or whether there is a requirement to deliver more domestic abatement. The flexible approach is considered first as it is the most likely scenario.

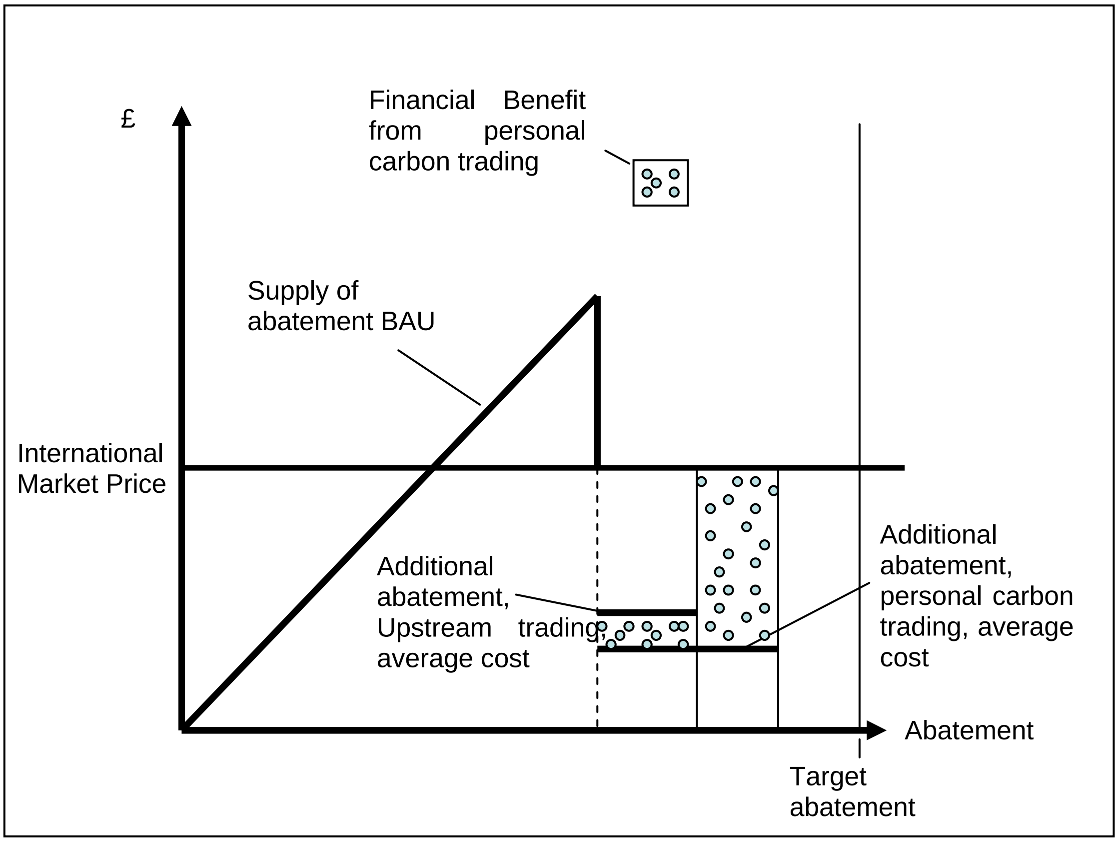
When the UK is achieving some of its target internationally, the supply of abatement can be represented as in Figure 10. The international abatement is all achieved at the market price for international credits, such as EU allowances. The overall cost to achieve the target is the area under the graph.

Figure 10: Cost of target reductions with international flexibility



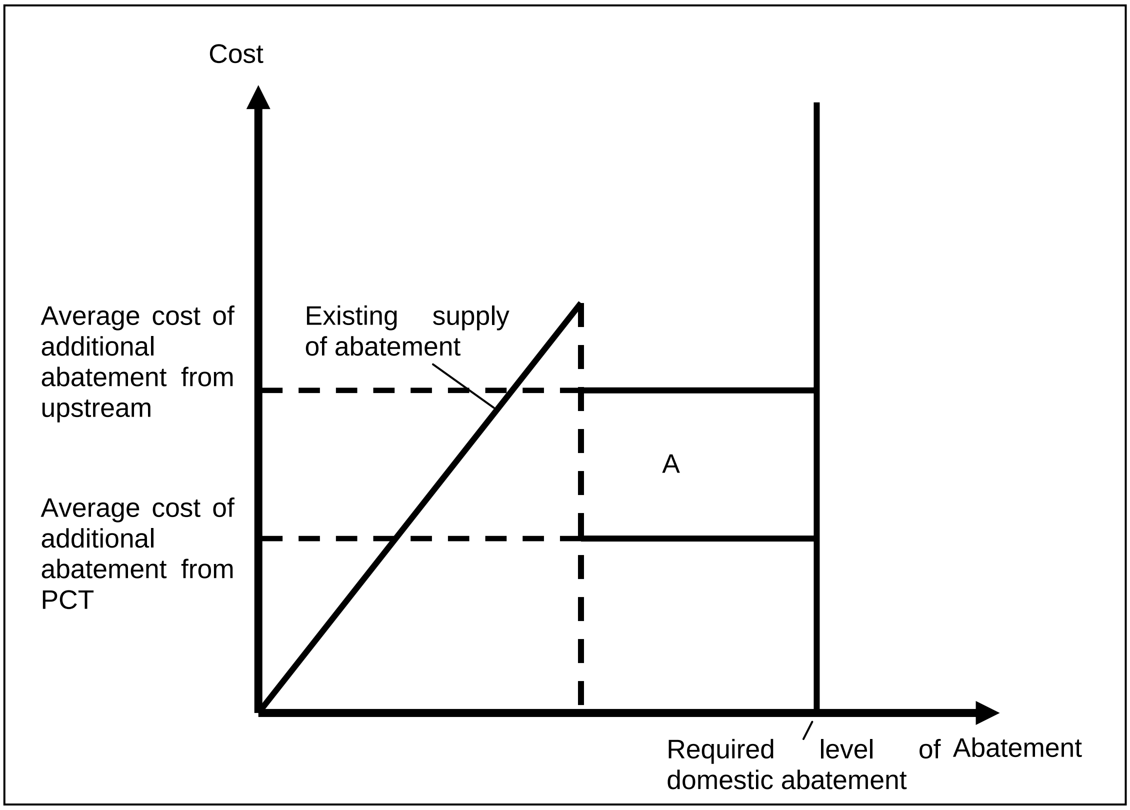
When personal carbon trading, or upstream trading are introduced with a soft cap, they would be expected to deliver some additional domestic abatement through their impact on barriers. Personal carbon trading could deliver more, due to the additional impact of the visibility that it creates. Figure 11 provides an illustration of the additional financial benefit of personal carbon trading over upstream trading. The shaded area illustrates the reduced cost to the UK of achieving its emissions reductions target with personal carbon trading implemented, as compared to with the implementation of upstream trading. Introducing personal carbon trading would cost more than an upstream trading scheme to implement. If the shaded area, is larger than the additional cost then the choice to implement personal carbon trading would show a net benefit.

Figure 11: Financial benefit of personal carbon trading



In the case of a hard cap, requiring an increased level of domestic abatement, the benefit of personal carbon trading over upstream trading is different. In this case it is the difference in the cost of delivering the extra abatement with a personal carbon trading scheme as opposed to an upstream scheme. It would be expected that the average cost of additional abatement would be lower with personal carbon trading due to the impact of the visibility. The rectangle labelled 'A' in Figure 12 illustrates the benefit of choosing personal carbon trading to deliver a fixed level of additional domestic abatement. If this reduction in costs is greater than the additional cost of implementing personal carbon trading, then there would be a net benefit for the UK from implementing personal carbon trading rather than upstream trading (for further details see Annex B).

Figure 12: Financial benefit with no international flexibility



Comparison of the costs

The costs of implementing a downstream trading scheme have been discussed in qualitative terms above (see page 52). This section will consider how the costs of an upstream trading scheme would compare. Estimates for the costs of implementing both an upstream scheme and personal carbon trading have been provided by a parallel report on the technical feasibility and costs of implementing personal carbon trading – these figures are used to assess the case for introducing personal carbon trading, and testing the sensitivity of the conclusions.

An upstream scheme would require that a system for auctioning allowances and a secondary market for them be established. For a personal carbon trading scheme that was part of a wider economy wide scheme these costs would exist too, but with a narrower scheme where allowances were simply allocated to individuals, there would be no need for an auction system to be implemented. However, the costs for implementing an auctioning system are relatively minor[54].

The number of participants in an upstream scheme would be considerably lower, numbering in the hundreds, which would significantly reduce the cost of

[54] The Impact assessment for the auction system for the EU ETS that is to be implemented put the costs at ~£2.5million. http://www.defra.gov.uk/corporate/consult/euets-phase2auction/impact-assessment.pdf

these systems. If it is assumed that the revenues are recycled through lowering taxes or increasing benefits then this would create only a very small cost for an upstream scheme. There would be no costs in terms of establishing a database of eligible individuals, or the ongoing administration of such a database. There would be no requirement for a payment infrastructure or the issuing of cards, and the maintenance of several hundred carbon trading accounts with limited functionality would be negligible. Enforcement costs would be lower, due to the small number of participants to audit and control. For coal for instance it is easier to control at the pit or the dock rather than in all the retail outlets in the country[55]. Individuals would experience no time cost from an upstream scheme, as it would simply raise prices. Finally perverse costs may differ, as the visibility of personal carbon trading may drive individuals to greater lengths to avoid the use of personal carbon allowances. Additional costs for personal carbon trading would be:

- Additional administrative and implementation costs
- Costs of agents time to participate in the scheme
- Additional enforcement costs
- Additional perverse costs

In the EU ETS it has been decided that the visibility benefits of a downstream scheme are sufficient to justify the extra costs when we are considering energy intensive users. When an agent is responsible for millions of tonnes of carbon emissions, if visibility delivers only a fraction of a percentage point reduction in emissions, it would justify significant additional expenditure on administering that individual. Similarly the CRC will provide a downstream trading scheme for less energy intensive businesses and the public sector from 2010. This scheme was largely justified in terms of the benefits of increasing to visibility of energy use within corporations. This shows that the principle that visibility can justify additional cost is well established. However the question for personal carbon trading is whether this argument still holds when individuals are issued with only 4 tonnes of carbon allowances not millions of tonnes. Indeed, if it is decided that there should be no overlap with the EU ETS, the individual would be issued with less than 3 tonnes of allowances due to personal carbon trading only covering the emissions from domestic primary fuel use and road transport fuel.

During the design process for the CRC a report was commissioned from NERA[56] which analysed coverage. It concluded that administration and transaction costs would overcome the benefits of the policy if universal coverage of businesses was attempted:

"If all half-hourly metered sites were covered by the scheme without any exemptions for relatively small energy users, the administrative and transaction costs would be significant and would outweigh the energy-savings delivered by the scheme under most plausible scenarios."

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[55] The technical feasibility report suggested that domestic fuels such as coal, paraffin, and coke would have to be treated at an upstream level.
[56] 'Options for the implementation of a New Mandatory UK Emissions Trading Scheme' NERA, 2006. http://www.defra.gov.uk/environment/climatechange/uk/business/crc/pdf/nera-enviros-report-060428.pdf

A minimum electricity use of 6000MWh a year has been adopted for the CRC on the basis that administrative and transaction costs would be too large for smaller businesses in comparison to the anticipated energy savings that would be achieved. The question arises as to why this would not be the case for individuals who use even less energy each.

A parallel report on the technical feasibility and cost of personal carbon trading has provided a range of figures for the resource costs of implementing and administering a personal carbon trading scheme, as well as providing indicative comparative costs for the implementation of an upstream scheme (Table 14). These figures enable low, central and high estimates to be made of the additional cost of implementing a personal carbon trading scheme, over and above an upstream trading scheme.

Table 14: Implementation costs per person per year[57]

	Lower Bound	Central estimate	Upper bound
Personal Carbon Trading	£21.68	£33.25	£44.81
Additional costs for Personal Carbon Trading above an upstream scheme	£20.50	£32.07	£43.63

The costs in Table 14 do not include any additional time burden costs from personal carbon trading. For a low estimate, a valuation of 2 hours lost leisure time per participant per year is used. The central estimate is 4 hours, and the high estimate is 6 hours. Valuations of these costs are shown in Table 15.

Table 15: Time burden costs per person per year from personal carbon trading

Lower bound	Central estimate	Upper bound
£10	£20	£30

The total additional costs from choosing to implement personal carbon trading rather than an upstream trading scheme are shown in Table 16.

Table 16: Total additional costs from personal carbon trading over an upstream scheme per person per year

Lower bound	Central estimate	Upper bound
£30.50	£52.07	£73.63

For personal carbon trading to show a net benefit, the valuation of the additional abatement that it delivers, as a result of the added visibility of personal carbon emissions alone, must be greater than these costs. How large the benefit for personal carbon trading is depends critically on the percentage reduction in personal carbon emissions and the valuation that is placed on this reduction.

[57] Set up costs have been amortized over ten years.

A reduction in personal carbon emission greater than 5% purely as a result of the raised visibility delivered by personal carbon trading is unlikely. Evidence for effectiveness of indirect feedback provides suggested savings of between 0 and 10% of personal carbon emissions[58]. Given that personal carbon trading would exist alongside other policies that deliver visibility, notably smart metering, and that much of the low hanging fruit in terms of technological measures will already have been delivered by other policies, additional savings, at the high end of this range, are highly unlikely to be realised. A figure of a 5% reduction in personal carbon emissions can be used as an upper bound for the additional abatement that personal carbon trading might deliver.

Central projections for UK emissions estimate personal carbon emissions will be 237 million tonnes of carbon dioxide in 2013 and 223 million tonnes in 2020[59]. Table 17 shows the valuation of the additional abatement delivered by personal carbon trading, where the reductions are valued at the Shadow Price of Carbon[60].

Table 17: Estimates of additional annual benefits of personal carbon trading in 2013

	Reduction in personal emissions	lower bound	central	upper bound
Benefit per participant	0-5%	£0	£3.45	£6.90
	0-10%	£0	£6.90	£13.80

Comparing the central estimate for the additional costs of personal carbon trading per person per year (£52.07) with the central estimate of the additional benefits (£3.45), it is shown that the costs are more than 15 times larger than the benefits. Even in the most optimistic scenario, where the costs are at the lower bound per participant per year (£30.50), and the additional behaviour change is at the upper bound (£6.90), the costs are four and a half times the benefit. As a result it seems unlikely that the additional cost is justified by the additional benefit. In the central case, personal carbon trading would deliver just over 5 million tonnes of additional abatement. This would come at a cost of approximately £500 per tonne.

Sensitivity

It should be noted that there is no direct evidence from the actual implementation of a personal carbon trading scheme as to how effective it would be. The range of 0 – 5% reduction in personal carbon emissions could be

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[58] Darby – "The effectiveness of Feedback on energy consumption", 2006. http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf

[59] This projection includes UK leisure aviation emissions from international departures and arrivals.

[60] It should be noted that this assumes zero net resource costs for the additional abatement delivered by personal carbon trading.

revised if new evidence emerged that the visibility delivered by personal carbon trading were more effective than anticipated in this report. The cost benefit analysis is also sensitive to the valuation of the carbon savings delivered by personal carbon trading, should the shadow price of carbon be revised in future. A revision could be made due to new scientific evidence pointing to larger damage costs from carbon, or revisions to the assessment of the costs associated with delivering abatement.

Figures 13,14 and 15 show the 'cost-effective space' for personal carbon trading for the low, central and upper cost estimates. The x-axis indicates the level of additional abatement delivered by personal carbon trading and the y-axis show different valuations of the abatement. The curved lines show the cost-effective boundary; above the curves the combination of abatement and valuation is sufficient to outweigh the cost. The different curves illustrate the sensitivity to the number of participants accounts that are required. With fewer accounts the costs would be smaller, and therefore the benefits required for personal carbon trading to be cost-effective would be lower[61].

Figure 13 illustrates that with a valuation of £30 for the net benefit of additional abatement delivered by personal carbon trading and with 50 million accounts, that an additional reduction of 40% in personal carbon emissions from visibility alone would be required for personal carbon trading to be cost-effective. If the valuation of the additional abatement was doubled, to £60/tonne, a 20% reduction in personal carbon emissions would be required.

Figure 14 provides the most optimistic view of the cost effective space. It is based on the lower bound of the costs estimate, and a halved time burden cost estimate. At the SPC valuation the level of behavioural change required for personal carbon trading to be cost-effective would still be high; at least a 24% reduction in personal emissions from the additional visibility alone.

[61] This method of presenting the sensitivities was suggested by Joshua Thumim from the Centre for Sustainable Energy.

Figure 13 : Cost-effective space for central costs

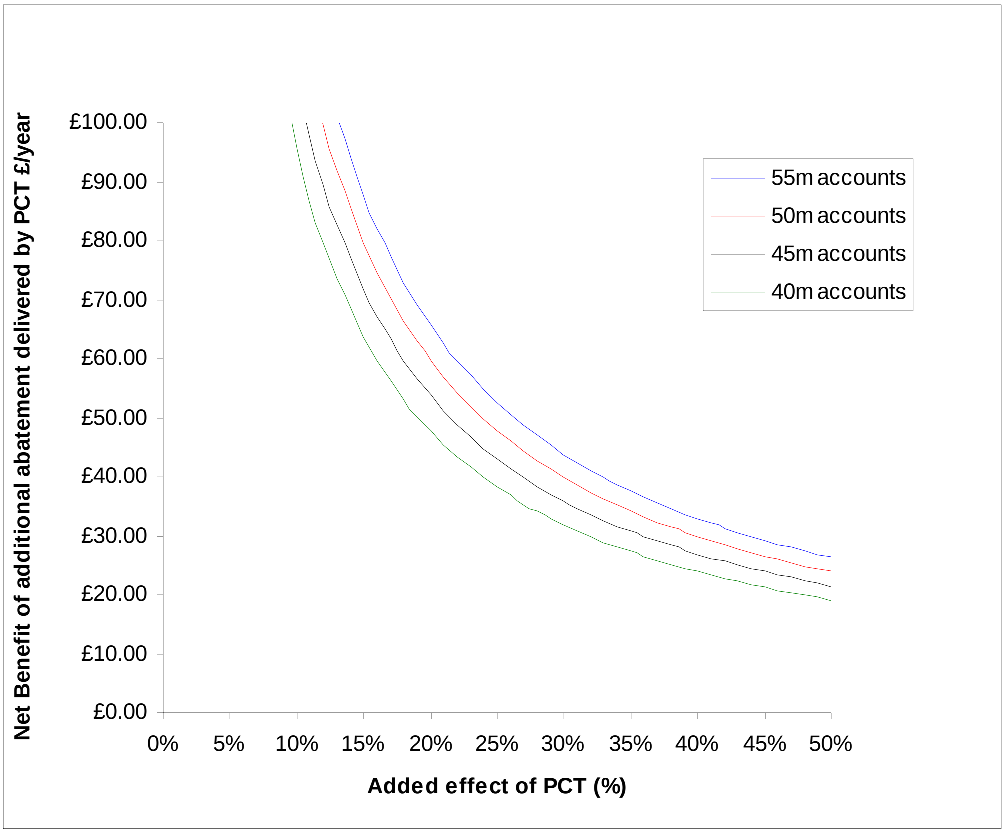
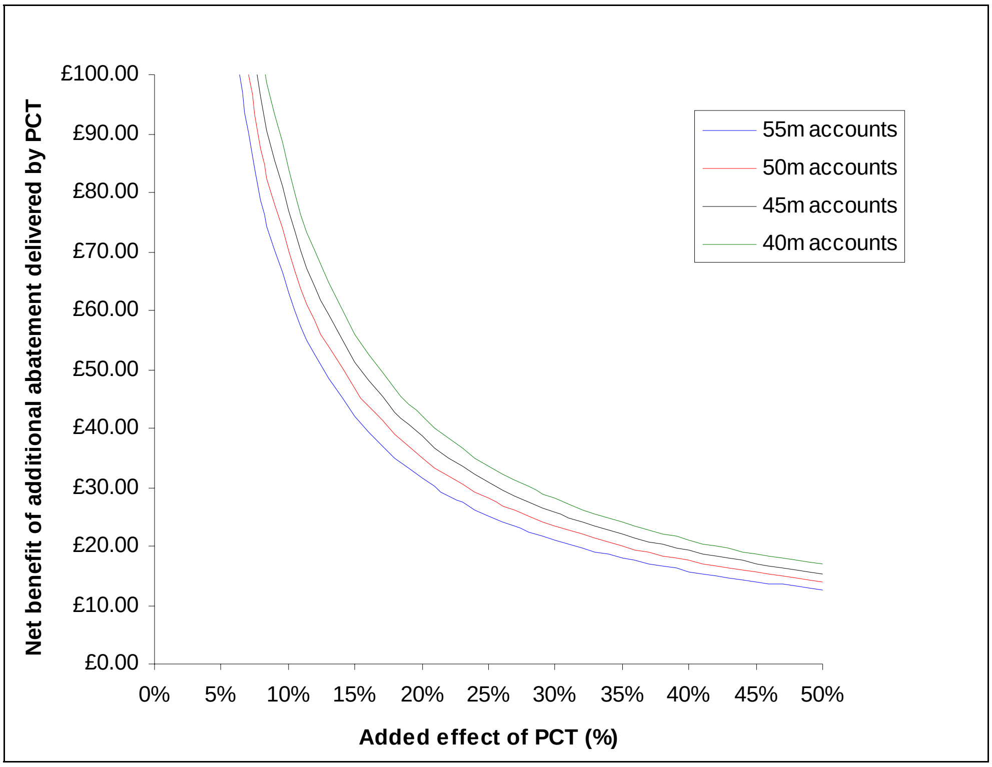


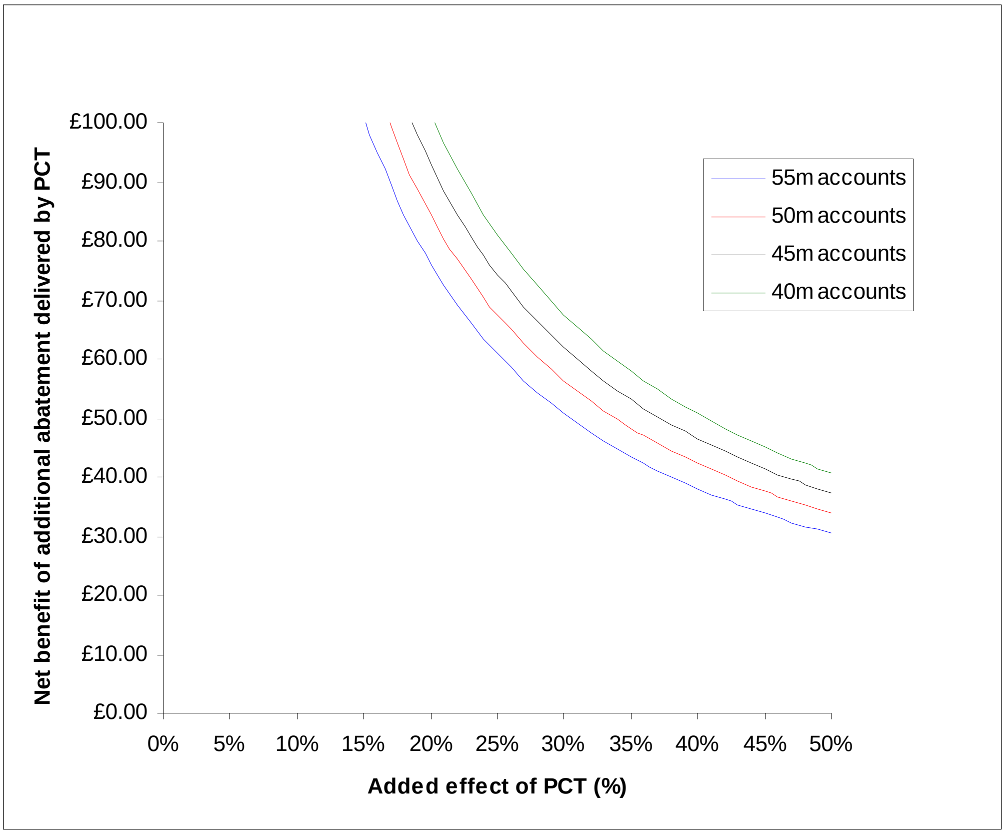
Figure 14 : Cost-effective space for lower bound costs



The most optimistic case presented in this paper for behavioural change was for a 5% reduction in personal carbon emissions. Taking this level of behavioural change and combining it with the lowest cost estimates represents the best case outcome for personal carbon trading. With a £30 SPC, even in this best case the costs would be 4.5 times the benefits.

There is a possibility that the costs may be at the high end of the range identified. Figure 15 illustrates the cost-effective space for personal carbon trading in this case. With a £30 valuation of additional abatement, the visibility would need to drive more than a 50% reduction in personal carbon emissions to be cost-effective.

<u>Figure15 : Cost-effective space for high costs</u>



There would need to be very significant revisions of the central figures used in this cost-benefit analysis for personal carbon trading to show a net benefit. Should the valuation of carbon savings be revised up sharply, combined with evidence of larger behavioural changes due to the visibility delivered by personal carbon trading, and a method of implementing personal carbon trading at significantly lower cost be found, then there may be a case for re-considering the conclusions of this report. However it would require *significant* revisions.

7 Conclusion

The survey of policies that impact on personal carbon emissions showed that the present policy mix is not successfully addressing all barriers to the uptake to abatement. The increasing demand for energy services was illustrated, highlighting the importance of policies that increase the visibility of personal carbon emissions to an overall policy strategy. However this does not provide a justification for any policy that delivers visibility. It is necessary to show that the type of visibility that is delivered by the new policy is additional to that being delivered by other policies and that it will translate into sufficient additional cost effective abatement to offset the cost of implementing the policy. Furthermore it is necessary to show that the type of visibility could not have been delivered more cheaply through another policy.

The issue of whether the additional cost of the policy can be justified is particularly acute for personal carbon trading which carries a high cost. All the benefits of personal carbon trading aside from visibility could be delivered more cheaply by other policies. Much of the visibility is already being delivered by other policies or could be delivered by low cost regulation. This creates a challenge. For personal carbon trading to be cost effective, it would be necessary to show that the incremental increase in the visibility of personal carbon emissions it would deliver could translate into sufficient behavioural change to justify the additional cost of implementing it.

The additional costs of implementing personal carbon trading can be assessed by comparing the costs of implementing it with the costs of implementing an upstream trading scheme which covers the same sectors. The extra expense of implementing and administering a personal carbon trading scheme in comparison to an upstream scheme 'buys' the extra visibility, is it a good purchase?

Even with an optimistic assessment of the impact of the additional visibility, a high valuation of the additional carbon savings delivered by personal carbon trading (assuming zero net resource costs to achieve the abatement) and using the low end of the range of costs for implementing the scheme, the costs are estimated to be four and a half times the benefits. In the central case the costs are fifteen times the benefits and the cost of the additional abatement would be approximately £500/tonne. As a result it seems unlikely that personal carbon trading would be able to pass a cost-effectiveness test. However the analysis of the overall policy mix and the importance of raising the visibility of personal carbon emissions should be noted. Other policies that could increase the visibility of personal carbon emissions should be explored.

Annex A

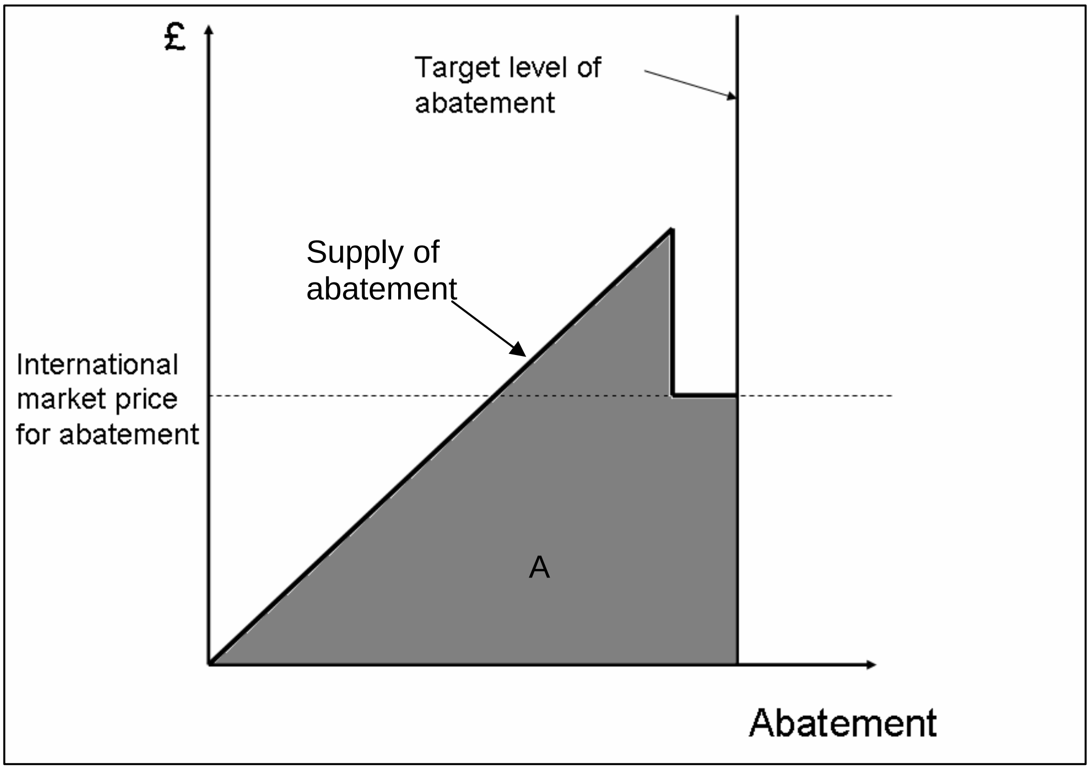
The financial benefit to the UK from Personal Carbon Trading

The impact of introducing personal carbon trading on the cost to the UK of reaching its emissions reductions targets is outlined below. For this approach to be valid, some assumptions are required.

- The UK will achieve its emissions reductions targets as laid out in the Climate Change Bill.
- These targets will be met with a mixture of domestic abatement and international abatement that the UK funds through international mechanisms.
- The level of domestic abatement prior to the introduction of personal carbon trading is sufficient to meet supplementarity requirements that place a minimum requirement on the proportion of abatement to be achieved domestically.
- That the policy mix that exists before the introduction of personal carbon trading will not deliver more abatement than is required to achieve the target reduction.

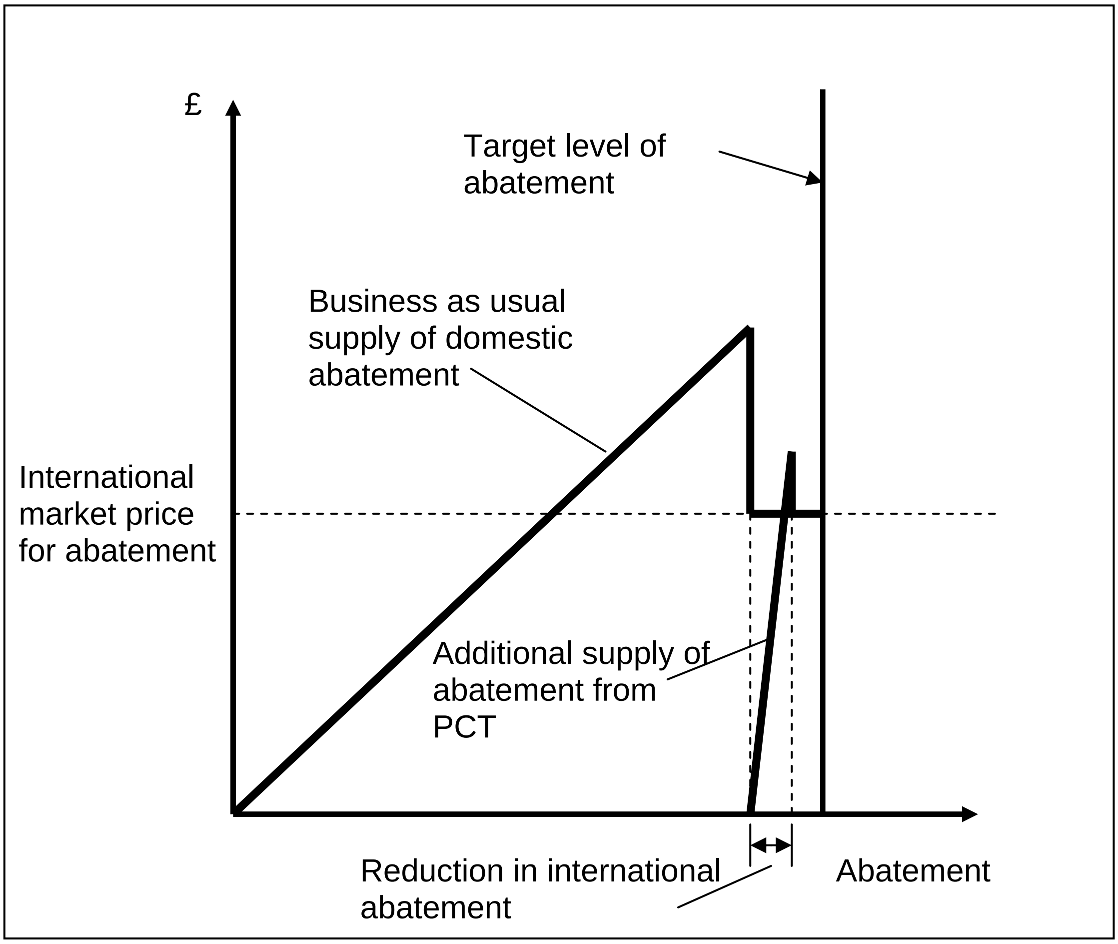
Given these assumptions, the cost to the UK of achieving its target is the shaded area A in the Figure 16 below. The policies are delivering a proportion of the abatement domestically; the remainder is paid for internationally. Some of the domestic abatement will cost less than the international abatement, and some will cost more, shown by the supply of abatement line going above the price of international abatement.

Figure 16: Cost of achieving Climate Change Bill target with international flexibility



The introduction of personal carbon trading would alter the domestic supply of abatement. Through the reduction of barriers it could result in additional low cost abatement being available in the UK. It could also result, if individuals trade irrationally, in additional expensive abatement being delivered in the UK. An example would arise in the case where individuals react to their allocation as a target and install expensive micro-generation measures. The graph below shows how the change in the supply of domestic abatement would affect the overall cost to the UK.

Figure 17: Supply of abatement with Personal Carbon Trading



The additional abatement will result in less international abatement being necessary to achieve the target, this results in a financial saving for the UK. However this saving must be compared with the cost of the additional abatement that personal carbon trading delivers. The net benefit to the UK will be:

Benefit = Q*(£Int - £PCT)

Where: Q = the quantity of additional abatement delivered by PCT
£Int = market price for international abatement
£PCT = average cost of abatement delivered by PCT

Annex B

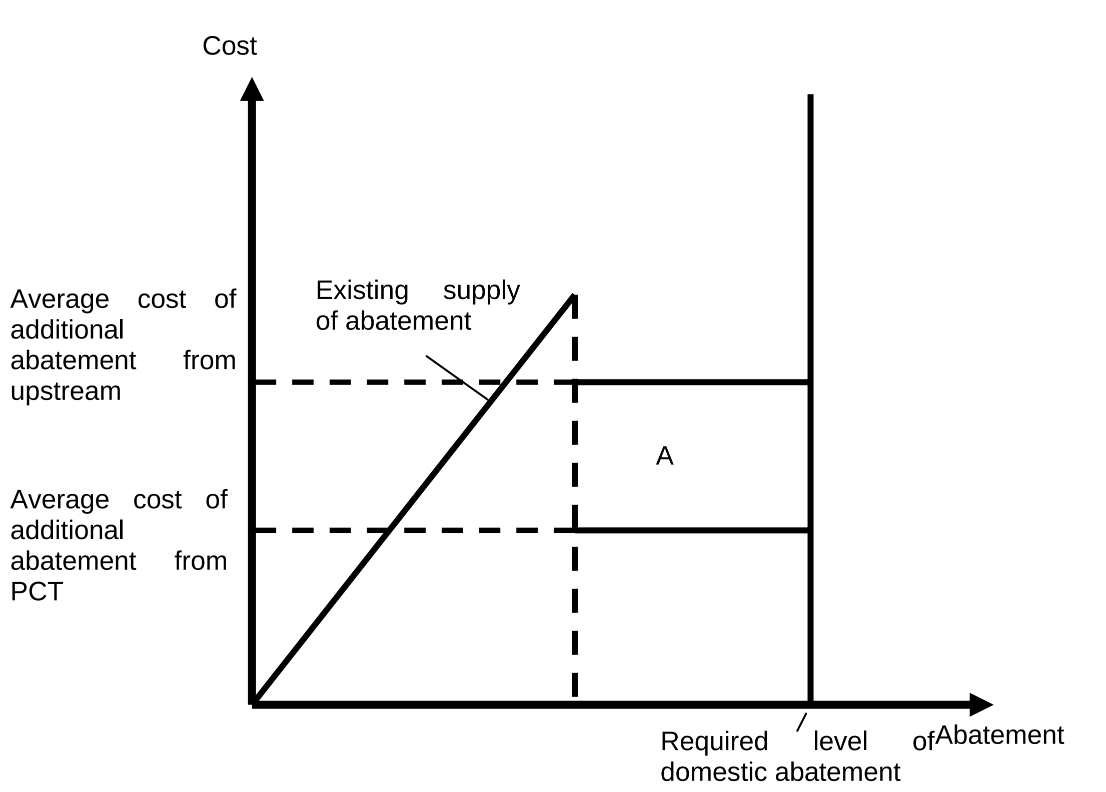
The financial benefit to Personal Carbon Trading when Climate Change Bill targets must be met through domestic abatement only

In the unlikely case that the UK tries to reach its emissions reductions targets through domestic abatement only, the financial benefit from personal carbon trading differs from the financial benefit when there is full international flexibility.

The targets could be reached with an upstream trading scheme and a collection of supporting policies or personal carbon trading with supporting policies. Indeed other policy regimes could achieve the target. The efficient policy choice would be one that minimises the cost of the resources used to deliver the abatement and to implement the policies.

Assuming that the visibility delivered by personal carbon trading more effectively addresses some of the barriers to low cost domestic abatement than upstream trading, it would be expected that the resource costs to deliver the abatement when personal carbon trading was implemented would be lower. However the cost of implementing the personal carbon trading would be higher than for an upstream trading scheme with complimentary policies. The question of whether personal carbon trading should be favoured would depend on whether the reduction in resource cost would be larger than the increase in implementation costs.

Figure 18: Abatement costs reduction from Personal Carbon Trading for domestic target



The diagram above shows the case where the saving in resource costs from implementing personal carbon trading is the shaded area A. Personal carbon trading delivers the additional domestic abatement required to reach the target more cheaply than the upstream scheme. If area A is larger than the additional cost of implementing personal carbon trading, then personal carbon trading would have a lower overall cost to the UK.

The difficulty in comparison to the flexible international approach is that it is harder to estimate how high the marginal cost of abatement would become, should the UK to achieve its targets entirely domestically. From the graph, it is difficult to estimate how high the average cost of additional abatement delivered by upstream trading would be, with which to compare the average cost of additional abatement from personal carbon trading. The upstream trading scheme's average cost could be significantly higher than the SPC, which assumes co-ordinated international action. The average costs with personal carbon trading could also be significantly higher than the SPC, though lower than for upstream trading. It would be expected that the visibility created by personal carbon trading would unlock additional low cost abatement in comparison to upstream trading, but if further abatement was required, personal carbon trading would rely on the carbon price to deliver further abatement. Just as with upstream trading, this may need to rise significantly to sufficiently constrain carbon emissions.

The policy of delivering all abatement domestically would be counterproductive were the cost of doing so to prove too high. The rationale for delivering a UK 'demonstration project' is that it would show leadership; proving that decarbonising a developed economy need not be economically damaging. Pursuing the policy even when it proved highly costly would only serve to discourage other nations from introducing ambitious climate change policies.

It is reasonable to assume that the average cost of additional abatement delivered by the upstream trading would be higher than the SPC. Any additional low cost abatement unlocked by the visibility created by personal carbon trading could therefore deliver a financial benefit that is greater than the SPC, net of abatement costs. How much higher is open to debate, but it is unreasonable to value it too much higher due to the fact that the domestic constraint on where abatement occurs would be likely to be loosened in the case that the 'demonstration project' proved highly costly.

Annex C

List of present or planned policies that directly or indirectly impact on the level of personal carbon emissions.

Aggregates Levy
Air passenger duty
Airline route development fund (NI)
Airline route development fund (Scotland)
Billing policy
‘Building a greener future, towards zero carbon development’
Building standards, England and Wales 2005
Building standards Northern Ireland, amendment 2006
Building standards Scotland 2007
Car advertisements must carry information about emissions
Carbon calculator
The Carbon Trust
CCL exemption for CHP
CERT (Carbon Emissions Reduction Target)
CHP R&D by Carbon Trust and EST
Climate Change Agreements
Climate Change Communication Initiative
Climate Challenge Fund
Climate Change Levy
Code for Sustainable Homes
Community Energy Programme
Company Car Tax differentials
Congestion Charges
Customer Levy (NI)
Cycle to Work Scheme
Decent Homes
Department for Transport Act on CO_2 campaign
Department for Transport information campaigns
Distributed generation policy
Duty incentives for bio-fuels
Dynamic Demand management
Eco-Driving included in the driving test
Enhanced Capital allowances for good quality CHP
Energy Efficiency Commitment 1 and 2 (though finished, have had an impact on remaining low cost abatement options in domestic sector)
Energy Performance certificates
Energy Saving Trust
Energy Saving Trust information campaigns
Energy Saving Trust ‘Recommended’ labelling
Energy Technology Institute
Energy Technology Institute (Transport)
Environment and Renewable energy fund (NI)
Environmental Action Fund
EU directive on Eco-Design

EU energy labelling
EU Exchange Trading System
EU voluntary agreements with car manufacturers
Every Action Counts
Exemption from business rates for some CHP plant
Fuel Duty
Fuel Quality Directive
Government support for research and development in the airline industry
Graduated Vehicle Excise Duty
Green Landlord Scheme
Green Homes service
Home Energy Conservation Act
Home Energy Efficiency Scheme plus (Wales)
Income from selling ROCs from micro-generation is income tax free
Landlord Energy Saving allowance
Light bulbs – agreement with manufacturers to phase out incandescent light bulbs from 2011
Local parking charges differentials
Low carbon buildings programme
Low carbon vehicle innovation platform
Low carbon vehicle procurement programme
Market Transformation Programme
Merton rules
Neighbourhood Renewal Funds
No Stamp Duty on Zero Carbon Homes
Pathfinder market renewal programme
Planning policy and CHP
Powershift
Product Bans
Real Time Display policy
Smart-metering
Reconnect (NI)
Reduced VAT on energy saving materials
Reduced VAT on micro-generation
Renewables Obligation
Reform of the Renewables Obligation
Renewable Transport Fuel Obligation
Scottish Householder and Renewables Initiative
Supplier Obligation
Transport Innovation Fund
Transport 10 year plan
VAT on domestic fuel and electricity
Vehicle Efficiency Labels
Voluntary agreement for phase out of incandescent light bulbs (2011)
Warm Deal
Warm Front
Warm Homes
Warm Zones
Winter fuel payment
Zero VAT on public transport

Annex D

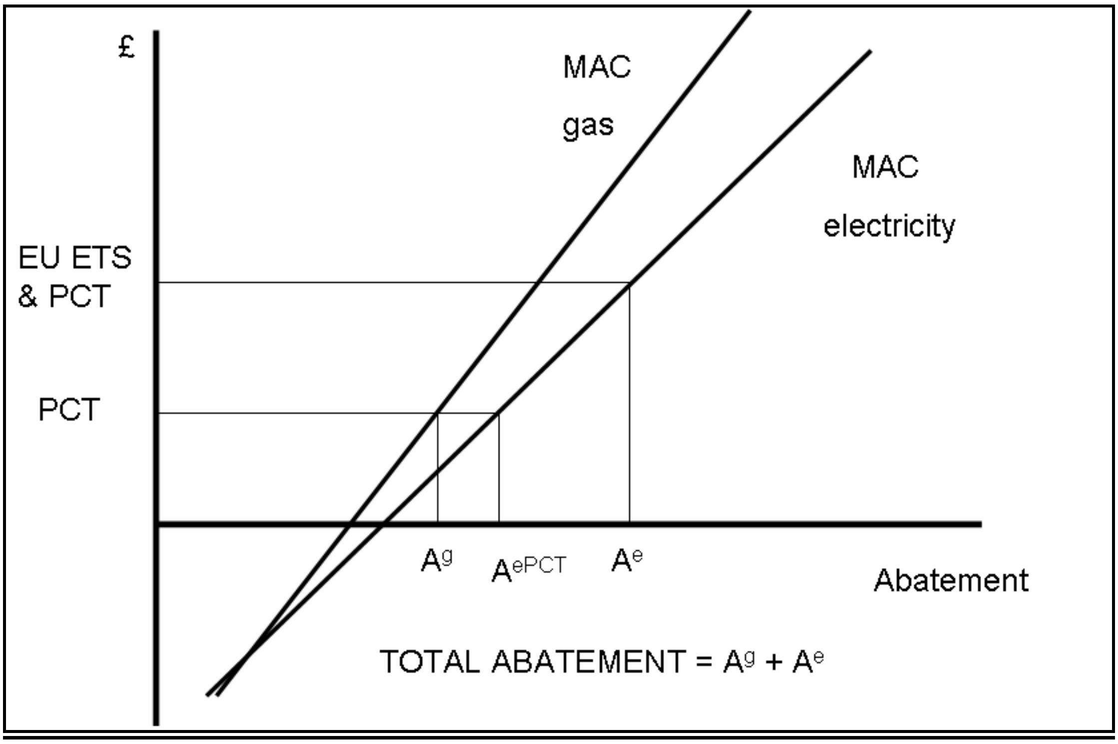
Inefficiency of overlapping trading schemes

Theoretically, partially overlapping trading schemes will result in inefficient abatement choices. The result is a larger overall cost to the UK of achieving a particular level of abatement than if there was a consistent economy wide carbon dioxide emissions price (referred to from now on as a carbon price). Why?

Consider the case where electricity is counted in both the EU ETS, and in the personal carbon trading scheme, whereas gas is only included in the personal carbon trading scheme. The EU ETS establishes a carbon price, which in large part is passed onto consumers. So for electricity consumers there is a carbon price included in the price they pay for their electricity as a result of the EU ETS. For gas, which is not treated within the EU ETS, there is no such effect. The personal carbon trading also establishes a carbon price, either explicitly, as individuals who have used up their allowance will have to purchase further allowances on the market, or implicitly, as by producing carbon emissions, individuals forego the proceeds from selling the allowances that they use up. This carbon price will cover both gas and electricity. The overlap of the two trading schemes will for electricity establish a higher carbon dioxide emissions price than the one for gas, as it will be formed through the effect of both emissions trading schemes.

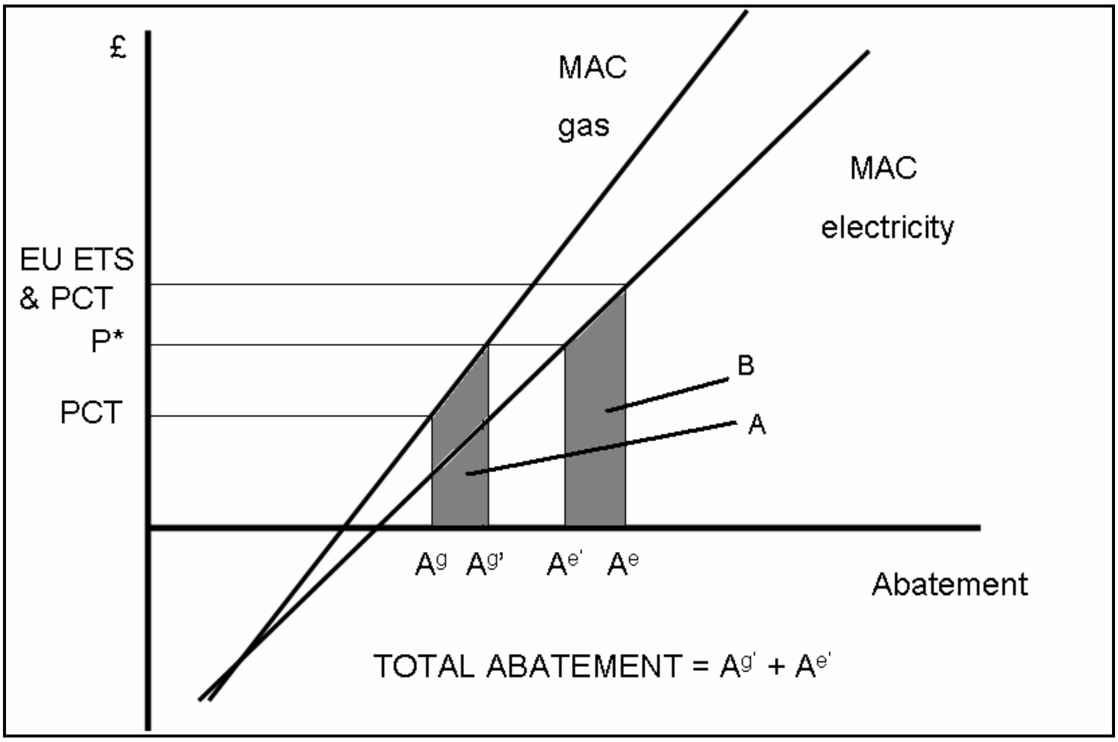
Figure 19 illustrates with differing carbon prices what the optimal level of abatement would be for processes that use both gas and electricity. The optimal abatement would occur for gas at A^g and for electricity at A^e. If electricity had been treated only in personal carbon trading, then the optimal abatement would be at a lower level, A^{ePCT}.

Figure 19: Abatement with differing carbon prices



The total abatement would be the combination of the abatement produced in emissions from both electricity, and gas. $A^g + A^e$. Could this level of abatement have been achieved more cheaply? Yes. Consider an economy wide carbon price of P*, as it is higher than the carbon price in the personal carbon trading scheme it would result in more abatement from activities using gas, resulting in the increased expenditure shown by the shaded area A. However as it is below the carbon price achieved through the overlap of the two schemes, it would result in less abatement from electricity using activities. This will result in the reduction in expenditure, shown by the shaded area B. The total level of abatement is the same because the increase in the abatement from gas offsets the reduction in abatement from electricity. Yet the level of expenditure is lower – the decrease in expenditure, B, is larger than the increase in expenditure A. So a consistent carbon price results in a lower overall cost of abatement to the UK economy.

Figure 20: Inefficiency of abatement with differing carbon prices



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