

Author

Tina Fawcett, Environmental Change Institute, University of Oxford & UK Energy Research Centre

Title

What would a strategy of demand reduction mean for the UK?

1 Abstract

In the UK, between 1990 and 2003, energy used directly by individuals within homes and for personal transport has increased. In total, carbon emissions from these energy uses have also risen. Despite or perhaps because of these trends there is renewed interest in 'demand reduction' as a method of reducing carbon emissions. Demand reduction is one of the key research themes within the new UK Energy Research Centre. But what would a strategy of demand reduction for the UK mean?

Demand reduction is examined for three sectors of direct personal energy use: household energy use, land travel and air travel. The paper demonstrates how the main influences on carbon emissions – the carbon intensity of fuels, energy efficiency and demand for mobility / energy services – have evolved since 1990. There have been improvements in adopting lower carbon fuels and energy efficiency, but at the same time a significant increase in demand for mobility / energy services, resulting in an overall rise in emissions. It is therefore concluded that reducing demand for mobility / energy services is a vital aspect of demand reduction.

The need for a focus on mobility / energy services is contrasted with current UK policy which is primarily reliant on energy efficiency to deliver carbon savings. An alternative policy approach – the introduction of personal carbon allowances – is described. Personal carbon allowances would be a means for reducing demand for both energy services and mobility as well as improving energy efficiency and the carbon intensity of fuels. This policy is one example of what a strategy of demand reduction could mean for the UK. The paper concludes by setting out a broad research agenda for demand reduction.

2 Introduction

Demand reduction is one of the key research themes being undertaken by the recently created UK Energy Research Centre (UKERC). This paper questions what 'demand reduction' means and suggests that the boundaries of energy research need to be expanded if UK carbon emissions from the residential and personal transport sectors are to be reduced. To understand why a more comprehensive and radical approach to demand management is required, the best starting point is a brief review of UK and global carbon dioxide emissions.

Worldwide greenhouse gas and carbon dioxide (CO₂) emissions continue to rise, and the atmospheric concentration of CO₂ increased from 354 parts per million (ppm) in 1990 to 376 ppm in 2003 (Keeling and Whorf 2004). There are fears that a 'safe' level of CO₂ in the atmosphere may soon be exceeded. For example, the recent report of the International Climate Change Taskforce claims that 400ppm is likely to represent a point of no return, beyond which climate change could spiral out of control (ICCT 2005). If this is true, at recent rates of increase we are less than twenty years away from this critical point.

The latest carbon emissions data from the DTI (2005), which do not include emissions from international air travel, shows that UK emissions are on an upwards trend from the late 1990s onwards (Figure 1). Furthermore data on UK fuel use so far in 2005 suggest carbon emissions are likely to rise further in 2005 (Brown 2005). This contrasts with the longer term trend since 1970 which has been downwards (data from 1970-1990 is only available on a UNECE basis – which is slightly different from the IPCC basis used for Kyoto targets).

However, when the carbon equivalent emissions of international air travel are added to the UK IPCC carbon total, total emissions increase and the upwards trend emerges at an earlier date, due to the growth in air travel during the period.

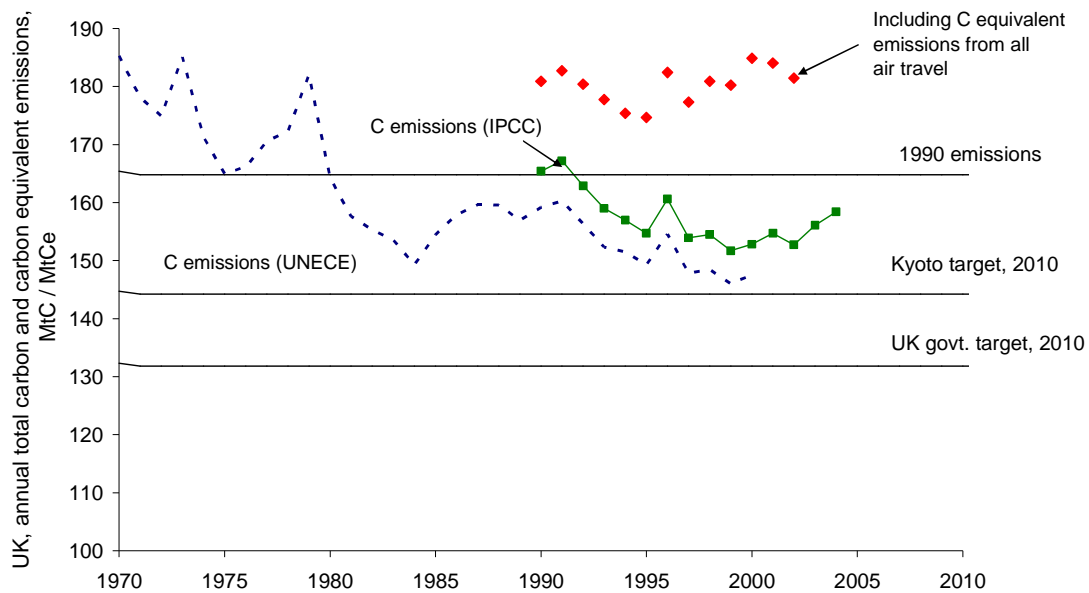


Figure 1: UK total carbon emissions and carbon equivalent emissions including international air travel, MtC / MtCe, 1970 - 2004

Sources: DEFRA 2003; DTI 2005; ONS and NETCEN 2004

The government has admitted what had long been suggested by commentators, that it will not meet its goal of a 20% carbon reduction by 2010 given current policies (DEFRA 2004). But it claims it is still on target to meet its Kyoto target. This is possible because despite the minor reductions in carbon dioxide emissions, there have been greater reductions in the other five greenhouse gases which complete the 'basket' of six gases to which the 12.5% Kyoto reduction target applies.

The UK has also adopted a 60% carbon reduction target by 2050 (DTI 2003). One way of meeting this target would be a steady reduction in emissions of around 2% per year from the 1990s onwards. However, between 1990 and 2004, carbon emissions from the UK (excluding international aircraft emissions) have only fallen by 4.2%. Clearly, an emissions reduction of 2% per annum would require a considerable change from present trends. In addition, the 60% reduction target is premised on the assumption that a maximum CO₂ concentration in the atmosphere of 550 ppm would be 'safe' (RCEP 2000), an assumption the latest research does not support (ICCT 2005). Further and faster cuts in national carbon emissions will be necessary if the UK is to play its part in ensuring carbon dioxide concentration levels in the atmosphere do not lead to dangerous climate change.

3 Demand reduction overview

Demand reduction is one of the six research themes being undertaken by the UK Energy Research Centre (UKERC). The initial definition of the role of demand reduction within UKERC was that it would "...address the challenge of reducing demand for energy through the introduction of new technologies and influencing consumer behaviour while addressing concerns about distribution and affordability." To reduce the demand for energy (and thereby resultant carbon emissions) it is first necessary to understand the sources of this demand and how they can be modified.

Figure 2 illustrates how demand for energy services / accessibility / mobility is translated via energy use into emissions of carbon dioxide. This simplified diagram identifies the key roles of energy efficiency and the carbon intensity of energy sources in influencing resultant carbon emissions.

In the residential sector, 'energy services' is a phrase which encompasses the benefits people get from using energy in their homes – e.g. warm rooms, hot showers, well-lit spaces, access to the internet. For surface transport, 'accessibility' has a similar meaning to energy services. It is a description of what people hope to gain from using transport, and can be defined as the ability to interact socially, to work or make use of goods and services. Demand for energy services is very varied, difficult to define and even more difficult to measure. The same is true of accessibility. While analysing and understanding demand for energy services and accessibility is very important in identifying opportunities for reducing carbon emissions, these concepts are more difficult to work with than simple energy use.

Demand for energy services in the residential sector is mediated by many intervening factors to result in demand for energy (these are simplified in the figure to two key influences). For personal surface transport the picture is more complex. A desire to access certain services may involve motorised travel, depending on the location of the service relative to the person or how the service can be accessed. For example, the telephone service 'NHS Direct' provides a means of accessing health advice and information without requiring a trip to the doctor / hospital. Once a journey is necessary, mobility is translated into energy use via a combination of the mode of transport and the energy use per passenger-km of that mode. For air travel, the energy impact of a particular trip depends on the energy used per passenger-km.

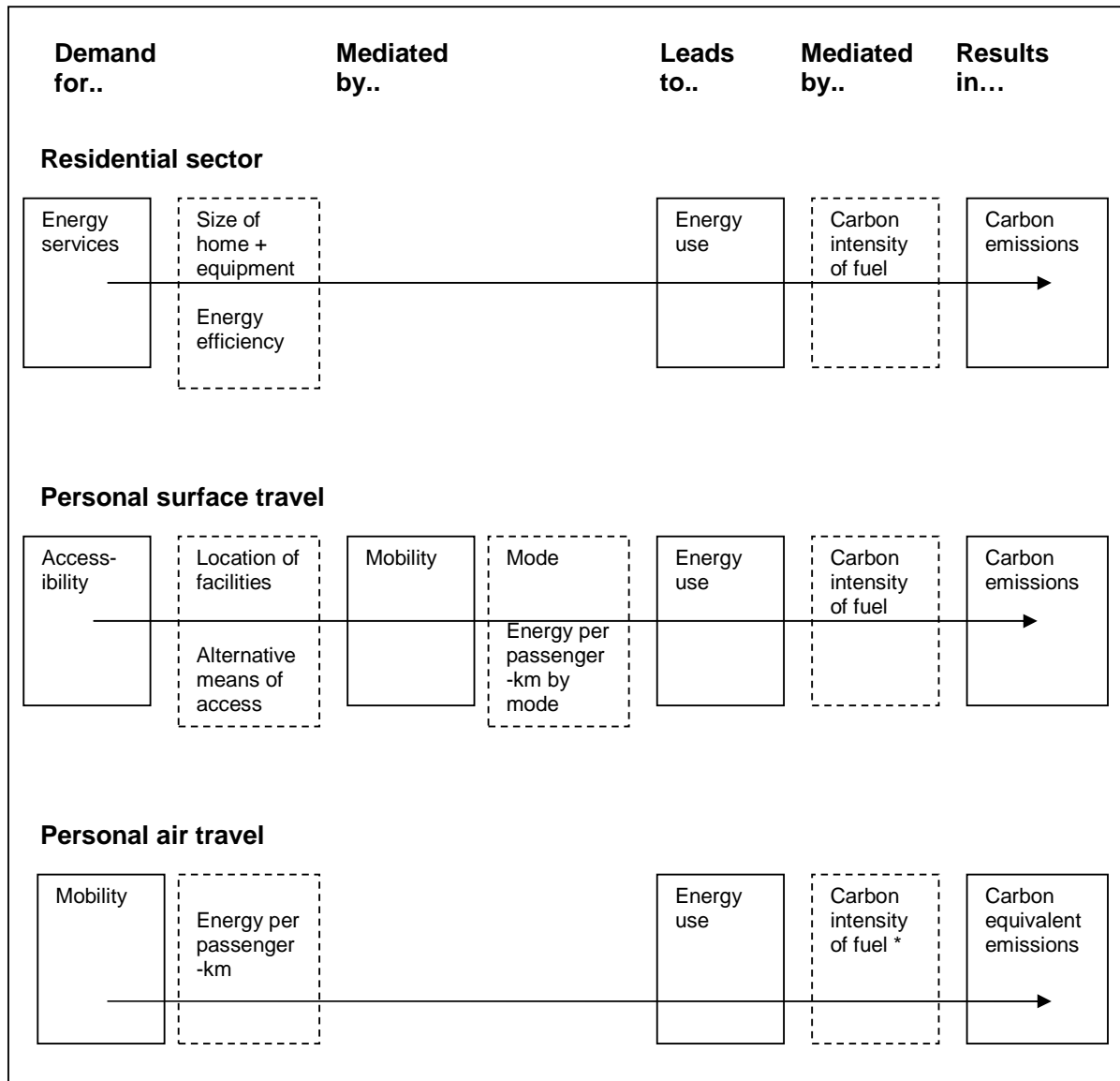


Figure 2: The relationship between demand for energy services / accessibility and carbon emissions

* In practice, there is only one known aircraft fuel, and lower carbon alternatives are not expected within the foreseeable future (RCEP 2002).

This figure does not include an explanation of what pre-cursors drive demand for energy services and accessibility / mobility. Factors driving demand for additional energy services would include the cost of energy, wealth, social norms and the availability of new energy-using technologies and services.

4 Household and personal transport energy use and carbon emissions

Trends to date

Carbon emissions from personal surface and air travel have increased and those from the residential sector decreased only very slightly since 1990 (Table 1). Thus these sectors are not contributing to the required reduction in UK carbon emissions.

Carbon emissions are a product of the carbon intensity of fuels used, the efficiency with which energy is used and the demand for energy services / mobility. Table 1 demonstrates how each of these contributing factors has changed over the same period. The carbon intensity of fuels has remained the same for air travel. Carbon intensity has fallen in the other sectors. Energy efficiency improvements have been seen in air travel and the residential sector. However, despite these factors which contribute towards lower carbon emissions, the increasing demand for energy services and travel has resulted in increased or only slightly decreasing emissions, at a time when strong cuts are needed.

Table 1: Contribution to meeting carbon reduction targets, 1990-2003

	Personal air travel	Personal surface travel (DfT 2004)	Household energy use
Carbon emissions	Strong increase C emissions from international air travel increase 85% 1990-2002 (ONS and NETCEN 2004)	Increase C emissions from road transport increase 10.5% 1990-2001	Slight decrease C emissions decrease only 0.5% 1990-2001 (DEFRA 2004)
Carbon intensity of fuels	No change	Reduction Switch to diesel in cars gives lower C/km.	Reduction Lower C electricity & greater use of gas.
Energy efficiency	Increase Continuing historical improvement trend (RCEP 2002)	Mixed Vehicle efficiency of new cars improved. Journeys less efficient, higher car usage, lower car occupancy.	Increase Building shell and equipment more efficient.
Mobility / energy services	Strong increase Distance travelled per person per year increasing rapidly.	Increase Total passenger distance travelled up 15% 1990-2003.	Increase Increase in household numbers, higher internal temperatures, more ownership of electrical goods etc.

Future trends

Projections of future demand for energy or carbon emissions from these sectors show that growth is expected.

- Growth in air travel is expected to continue. The latest UK government projections suggest a mid-range forecast of 4.25% growth per year from 1998 to 2020 (DfT 2000). This increase will overwhelm the much lower expected improvements in efficiency per passenger kilometre (RCEP 2002). Given that no change is expected to the carbon intensity of fuels, carbon emissions from air travel are expected to continue to grow strongly.
- Carbon emissions from road transport are expected to increase to 2020 even taking into account policy measures which were in place when the projections were made, e.g. the EU agreement on improving efficiency of new vehicles (DTI 2004a). The projection is for a greater than 20% increase in emissions between 2005 and 2020.
- For the domestic sector, the latest energy projection from DTI suggested that energy use would decrease from 545TWh in 2002 to 528TWh in 2005 (DTI 2003). Actual figures for 2003 show energy use of 557TWh – an increase rather than the projected decrease (DTI 2004b). Although falling carbon intensity of energy (particularly electricity) has in recent years offset increases in energy consumption, this trend is not expected to continue.

As in the past, it is likely to be the underlying demand for energy services, accessibility and mobility that drive upwards the use of energy, resulting in increasing carbon emissions. There is clear evidence that energy services we now take for granted as necessities were once regarded as unnecessary or luxurious. For example, in a nationally representative survey carried out in 1977, 49% of respondents agreed or agreed strongly that ‘it is not generally necessary to heat bedrooms’ (Field and Hedges 1977). Evidence shows attitudes have changed considerably over twenty years: by 1996, just 3% of English households did not heat bedrooms at the weekend (DETR 2000a). This process of renegotiation of what are regarded as basic needs, in the direction of increasing consumption of energy and other resources, is very clearly not at an end.

A few examples show where new demands for energy services and mobility are arising. Patio heaters are increasingly popular. They have an output range which is typically up to 12.5 or 14kW which is the same range as many new condensing boilers used for heating entire houses. In another example of new demands for energy services becoming normalised, air conditioning in cars has become a standard specification in most new cars. It increases energy consumption by up to 15%, adds to weight of car and leaks refrigerants which are themselves greenhouse gases (Hillman and Fawcett 2004). Finally, travellers are being persuaded to consider ever more distant destinations as suitable for weekend breaks. For example, this from The Guardian:

“New York is still our favourite for a weekend shopping break. The January sales are legendary, and the crisp winter weather will remind you of how British winters used to be before global warming.” (Bindloss 2003)

Technological approaches to carbon saving and improved energy efficiency can do nothing to influence the likely uptake of these energy using options, the best which can be hoped for is to reduce their impact.

To summarise, improved technology has not been sufficient to reduce energy / carbon demand in the past. Future projections are for increases in energy use and carbon emissions, and there are many opportunities for all of us to increase the usage of energy in our everyday lives. Technological improvements do not tackle the underlying growth in demand for energy services and mobility. Therefore, new solutions must address this driving force.

5 Approaches to demand reduction

Existing policy

Government policy is to meet and exceed its Kyoto commitments. This requires reductions of carbon dioxide emissions from the whole economy, excluding international aviation which is currently outside the terms of the Kyoto agreement. Within the residential sector, most effort is focussed on increasing energy efficiency, via a variety of policy instruments. These include efficiency standards for new buildings, home extensions, boilers, appliances and windows, subsidised or free schemes for efficiency improvement to existing buildings and various information and subsidy measures encouraging the uptake of efficient lighting and appliances. There is also policy addressing carbon emissions from electricity. Most of this focuses on supply side renewable energy policies. For the transport sector, the key policy in terms of expected carbon savings is an EU-wide agreement on reducing the carbon emissions per km from new cars (DTI 2004a). There is no significant government policy aimed at reducing demand for air travel, rather expansion of activity in this sector is being encouraged and planned for. Thus, current policy focuses on not on reducing demand for energy services, accessibility or mobility, but instead tries primarily to increase the efficiency with which these services are provided.

This reliance on efficiency for meeting goals other than the more efficient use of energy has a long history. For example, in the residential sector, energy efficiency has been used as a means to meet three different policy goals over recent decades: energy conservation, economic efficiency and carbon

emissions reduction. The oil price energy crises in the 1970s prompted governmental and public interest in better management of energy. There was considerable concern that fossil fuels were in short supply and that the world was running out of them. Energy conservation became an explicit focus of government attention, with public education campaigns such as 'Save it!' (Jones 1995). At this time energy efficiency was seen a means to achieve energy conservation. During the 1980s, oil prices fell and the focus on energy conservation diminished. There was considerable attention on justifying public investment in energy efficiency from an economic standpoint. Economic arguments were developed to demonstrate that the market would deliver less than optimum levels of efficiency due to market imperfections such as lack of information. During this period, energy efficiency was partly promoted as a means of improving economic efficiency. In the mid to late 1990s, climate change concerns became an increasingly important factor in energy policy. Energy efficiency was once again seen as an important policy, this time as a tool for achieving carbon emission reductions and also for helping to reduce fuel poverty (DETR 2000b). This re-invention of the role of energy efficiency to fit the energy policy goals of the time can be argued to put too much reliance on efficiency policy to deliver targets other than the more efficient use of energy.

Explicitly encouraging a reduction in demand for energy services and accessibility / mobility is not a major part of government policy. Within the residential sector advice may be given, for example, to reduce thermostat temperatures by 1°C to save 10% of energy. The general rise over time of indoor temperatures suggests this advice has not been widely heeded. For surface transport, there has been more of a history of trying to persuade people to reduce car usage in favour of less environmentally damaging modes:

"From the early 1990s... transport policy had a rhetoric and rationale of demand management - of measures to reduce car use, targets to increase rail, bicycle and bus use and a strong emphasis on reducing transport's environmental impacts. The current (2004) White Paper is totally different. ... The word 'environment' is there, but in reality is relegated to the sidelines. The central thrust is all about cutting traffic congestion and facilitating mobility." (Potter 2004)

Again, this has not been successful (or successful enough) as dependence on cars continues to increase over time (DfT 2004). Potter suggests even this limited effort is no longer occurring.

Moving towards reducing demand for energy services and accessibility / mobility

Energy policy researchers have been interested in the concept of energy services for some time. The assumption is that by focusing on energy services rather than energy use, more opportunities for reducing energy demand can be identified. However, few policy innovations seem to have emerged from this approach, other than the promotion of energy service companies (ESCOs) as a route to energy savings. However ESCOs have not become established in the residential sector, and some years ago analysis showed that an energy services market would only emerge in the UK with considerable policy support (Jones 2001).

Within the surface transport sector, the switch in focus from mobility to accessibility allows a more profound re-thinking of how services people want can be delivered. Accessibility can be enhanced without increasing mobility, by means such as land-use planning policy or through offering services by phone / via the internet. In the long term, a lower carbon transport system will rely on a profound change in geographical organisation such that essential facilities are located closer to people.

However, the danger with discussing energy services and accessibility is that these can be seen as non-negotiable 'needs', whereas in fact the level of energy services and accessibility which is taken for granted is constantly re-negotiated. Using the example of refrigeration, Wilhite and Lutzenhiser (1997) show how multiple influences, including working and shopping patterns, kitchen designers, and householders' wish to be seen as good providers, serve to increase the minimum size of refrigerator 'needed'. They demonstrate that what is now taken to be conventional and basic social hardware was once regarded as unnecessary, luxurious or even frivolous. Their conclusion is that there is constant

renegotiation of what are regarded as basic needs, usually in the direction of increasing consumption of energy and other resources.

As part of a demand reduction strategy it is vital that reducing demand for energy services and accessibility (and mobility in the case of air travel) is recognised as a legitimate aim of policy.

6 A new approach to demand reduction: personal carbon allowances

One new approach to demand reduction which provides a framework for reducing demand for energy services and accessibility, as well as for increased energy efficiency and reduced carbon intensity of energy sources is the concept of personal carbon allowances. Personal carbon allowances would be a UK-wide allowance system covering the carbon emissions generated from the fossil fuel energy used by individuals within the home and for personal transport, including carbon equivalent emissions from air travel. It would account for around half of current UK carbon emissions from energy. The primary aim of the scheme would be to deliver guaranteed levels of carbon savings in successive years in an equitable way. A parallel scheme would be required to cap and reduce carbon emissions from the other half of the economy. The proposal for personal carbon allowances is based on the same principles as the domestic tradable quota work being undertaken by the Tyndall Centre, although some details differ (Anderson and Starkey 2004).

Key features

The main features of personal carbon allowances are:

- An equal annual allowance is allocated for each adult, with a smaller one for children
- The allowance covers the energy used in the household and for personal travel
- Allowances are tradable
- A phased year-on-year reducing allowance is signalled well in advance
- The scheme is mandatory.

The least controversial aspects of the scheme are that the allowance should reduce over time and that the allowance system must be mandatory. Without these two aspects, savings could not be guaranteed. There is some debate about whether carbon emissions from air travel should be controlled at the airline company rather than personal level. However, the idea presented here covers all types of fuel-using transport which is used for personal reasons (rather than business travel), including journeys by air.

The aspects which generate most concern are the proposal for both equal and tradable allowances. The case for giving each adult the same allowance is that it is the most equitable possible system. It is based on the principle that everyone has an equal right to share the available atmospheric capacity for emitting carbon. (This is the same approach which informs the Global Commons Institutes' 'contraction and convergence' framework for international sharing of carbon emissions reduction (Meyer 2000).) The alternative, which is often suggested, is that people should be given an allowance according to their 'needs'. Under this model, rural dwellers could be given a greater allowance for travel than urban dwellers, and people living in inefficient homes greater allowances than those in efficient ones. However, car owners would also get greater allowances than those without, and flat-dwellers would lose out to those who need more allowances to heat their mansions. Frequent fliers would get a particularly large allowance, reflecting their 'need' to fly. While the 'needs' method of allocation is often suggested as a means to reduce the unfair effect of equal allowances, what it would do in reality is entrench the already privileged in their current position and reward those with higher carbon emissions. In addition, it would probably be impossible to assess individuals' 'needs' and allocate carbon credits accordingly. Equal allowances are not only fair in principle, they are likely to be the only allocation which can be agreed without endless special interest pleading.

Trading is an integral part of the carbon allowance scheme. Indeed, it is a necessary component given a system based on equal allowances and a current reality of highly unequal patterns of individual emissions. Although little is known about individual emissions, a pilot study has shown that annual personal emissions from a small sample of people in 2003 varied by a factor of twelve (Fawcett 2005). These large variations between people highlight the need for trading. Under a system of equal allowances, those who lead lives with a relatively low energy input by investing in household efficiency, renewables, and by travelling less will not need all of their share and will therefore have a surplus to sell. Those who live in large or inefficient homes or who travel a lot, will need to buy this surplus to permit them to continue with something like their accustomed lifestyle. A market can be created to enable this trading to happen as easily as possible, with carbon allowances being bought and sold in Post Offices, banks, petrol stations and so on.

Carbon allowances in practice

Administration should be relatively straightforward. Each person is given an electronic card containing the year's carbon credits. It would have to be presented for deduction of the correct amount of carbon on purchase of energy or travel services. The technologies already in place for direct debit and credit cards could be used. If, for example, people forgot their cards at the petrol station, it would be possible to simply buy carbon credits at the market rate when paying for the petrol.

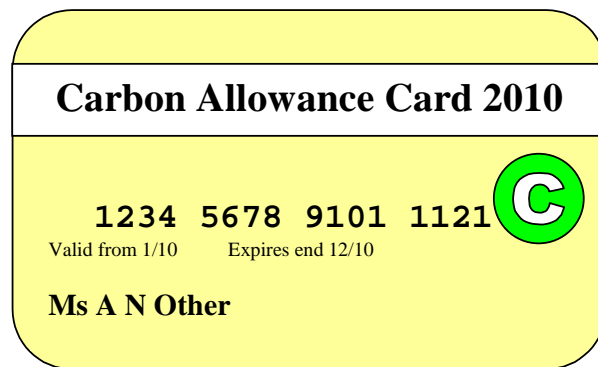


Figure 3: Illustration of a carbon allowance card

In order to make it easy for people to adapt to a new, lower-carbon world there would need to be many supporting policies to enable the right choices. These would include enhanced labelling of houses, cars, appliances, lights and airline tickets so the carbon consequences of purchase decisions would be very clear. Energy meters and bills would give customers much better feedback and information on their emissions. In addition, many companies and social enterprises would emerge to help people live comfortably on a reducing carbon allowance.

Political and policy interest

One of the most common criticisms of personal carbon allowances is that they will never be politically or publicly acceptable. Although such a policy is unlikely to be adopted immediately, it is already beginning to attract serious interest amongst decision makers. For example, Colin Challen MP (Labour) introduced a private member's bill in 2004 which called for the introduction of domestic tradable quotas. Recently the Sustainable Development Commission has said the government should fund much more research on this topic with the aim of coming to a view about the acceptability of carbon allowances within the next two years (Sustainable Development Commission 2005). The hope is that the wider and deeper debate about carbon allowances, which is urgently needed, is now beginning.

7 A research agenda for demand reduction

This paper has made the case that as well as continuing research into energy efficiency (including less energy intensive travel choices) and lower carbon fuels, research activity needs to address the possibilities for reduction in demand for energy services and accessibility. This will mean expanding the boundaries of energy policy. New areas of expertise may be required, and novel and more radical thinking will be necessary. Some ideas for a research agenda are outlined below.

Investigating the causes of increasing demand

It will be important to investigate the causes of increasing demand for energy services and accessibility / mobility. Some of these factors are well understood, e.g. the provision of new roads creates additional traffic, whereas other may not yet have received sufficient attention. In addition, a review of the literature on needs versus wants should be undertaken. This could follow on from an existing review by Owens and Cowell (2002). Their review found that some authors retained an aversion to distinguishing between wants and needs, while others have perceived a morally significant difference between 'goods of the needs category' and 'goods of the wants category'. Thus consensus has not yet been reached on this debate.

Alternative measures of economic and social well-being

Research about the role of demand inevitably leads into wider debate about the nature of well-being and the role of economic growth in our society. While GDP growth is seen as the key barometer of social progress, it may be difficult to move to a low carbon society. Whether or not this is the case, it will be important to build on existing work which looks at alternative measures of well-being. It might be possible to include more relevant measures within the government's sustainability indicators, which have recently been updated (HM Government 2005).

Benefits from a low carbon society

In making the case for reducing accessibility/ mobility and energy services, identifying additional benefits of these reductions (beyond the reduction of carbon emissions) will be important. This process has begun, with health and employment benefits having been identified at a recent UKERC seminar (Hillman and Fawcett 2005). This work should be built on and expanded.

Transitions

Another important subject identified at seminar was the transition towards a low carbon economy, both how it could be brought about and how to protect people, particularly workers, who lost out in the process. Much more research is needed into how the UK could manage the retreat from a carbon-intensive society and economy.

Links with research on sustainable consumption

Jackson and Michaelis (2003) have identified three different definitions of sustainable consumption have been identified: consuming differently, consuming responsibly, consuming less. This work clearly has strong links with debates about demand management, and what sorts of demand we need. Is the requirement for different demands, responsible demands or reduced demands? Existing research on consumption will inform this research.

Research into personal carbon allowances

There are many outstanding research, policy and political questions about personal carbon allowances. The UKERC demand reduction team agenda includes developing the methodology for measuring personal carbon emissions, comparing PCAs with alternative policies, researching the effects of PCAs on different groups, particularly the fuel poor, critically assessing the benefits and disbenefits of PCAs, and encouraging understanding and debate about PCAs within the research and policy communities and by the general public. Additional work is also planned at the Tyndall Centre. But as the Sustainable Development Commission has identified, a considerable expansion of research effort is needed on this subject.

More radical ideas

In his ground-breaking book of 1974, Ivan Illich calculated that the typical American worked for at least 1,600 hours in order to afford 7,500 miles of private motoring, thus achieving five miles per hour – a speed matched by people without cars who walk (Illich 1974). His analysis presented a novel way of thinking about speed and what it achieves. To get towards a significantly lower carbon economy, it is likely to be necessary to change our ideas about many current aspects of taken-for-granted consumption. Roger Levett's work, which questions the role of individual choice and promotes the benefits of collective choices, is one attempt to reframe current debates (Levett 2004). More of these attempts will be needed.

8 Conclusions

This paper began with the question: what would a strategy of demand reduction mean for the UK? This question has not been fully answered, but a start has been made. Initial analysis showed that carbon emissions from household energy use and personal transport were either standing still or increasing, in contrast with the need for significant emissions reductions. Emissions are being driven upwards largely by increasing demand for energy services and accessibility / mobility. Improvements in efficiency and the carbon intensity of energy have not been sufficient to offset the effects of increasing demand – and neither are they expected to be in future. Given this background, it is clear that a research agenda for demand reduction must include reducing demand for energy services and accessibility / mobility.

However, this conclusion raises new questions about how to research such issues and what policies might be able to bring about reductions in demand. The introduction of personal carbon allowances is one policy which could encourage reductions in demand for energy services as well as improvements in efficiency and the carbon intensity of energy. The most important benefit of carbon allowances is that they provide an equitable framework for delivering guaranteed carbon reductions. They are one example of what a strategy of demand reduction could mean for the UK. In addition, a wider research agenda has been outlined which would broaden energy policy beyond its existing boundaries in order to investigate options for delivering significant carbon savings.

Above all, the demand reduction approach calls for more radical thinking about solutions to our current climate crisis. The challenge for the research community is to provide strategies that can deliver carbon savings year-on-year, and to help prepare society and the economy for the considerable changes which may be needed to achieve this.

9 References

- Anderson, K. and R. Starkey (2004). Domestic tradable quotas: A policy instrument for the reduction of greenhouse gas emissions. Norwich, Tyndall Centre for Climate Change Research.
- Bindloss, J. (2003). January Sales. *The Guardian*. 21 December 2003
- Brown, P. (2005). Carbon dioxide emissions rise despite climate change pledge. *The Guardian*. 2 August 2005
- DEFRA (2003). eDigest statistics about: Global atmosphere. Published on the web: <http://www.defra.gov.uk/environment/statistics/globalatmos/gagccukmeas.htm> (accessed December 2003).
- DEFRA (2004a). News Release: UK Climate Change Programme review: consultation launch. Published on the web: <http://www.defra.gov.uk/news/2004/041208b.htm>., Department for Environment, Food and Rural Affairs, London.
- DEFRA (2004b). 2002 UK air emission estimates and climate change sustainable development indicator. London, Department for Environment, Food and Rural Affairs, London.
- DETR (2000a). English house condition survey 1996: Energy Report. London, The Stationery Office.
- DETR (2000b). Climate change: the UK programme. London, The Stationery Office.

- DfT (2000). Air traffic forecasts for the UK. London, Department for Transport.
- DfT (2004). Transport Trends: 2004 edition. London, Department for Transport.
- DTI (2003). Stage 1 results: DTI exercise to update energy and emissions projections. Published on the web: www.dti.gov.uk/energy/sepn/euets.shtml, Department of Trade and Industry.
- DTI (2004a). Updated UK energy projections: Working paper May 2004. Published on the web: Department of Trade and Industry.
- DTI (2004b). Digest of UK Energy Statistics 2004. London, The Stationery Office.
- DTI (2005). "Carbon dioxide emissions." *Energy Trends*. March 2005
- Fawcett, T. (2005). Investigating carbon rationing as a policy for reducing carbon dioxide emissions from UK household energy use. PhD. University College London.
- Field, J. and B. Hedges (1977). National fuel and heating survey. London, National Consumer Council.
- Hillman, M. and T. Fawcett (2004). *How we can save the planet*. London, Penguin.
- Hillman, M. and T. Fawcett, Eds. (2005). Living in a low carbon world: the policy implications of rationing. Meeting Report DR1. London, UKERC.
- HM Government (2005). Securing the future: UK government sustainable development strategy. London, Department of the Environment, Food and Rural Affairs.
- ICCT (2005). Meeting the climate challenge: Recommendations of the International Climate Change Taskforce. London, IPPR, Centre for American Progress, Australia Institute.
- Illich, I. (1974). *Energy and equity*. London, Calder and Boyars.
- Jackson, T. and L. Michaelis (2003). Policies for sustainable consumption: a report to the Sustainable Development Commission. London, Sustainable Development Commission.
- Jones, E., Wade, J., Barton, D. (2001). *Residential sector energy services in the UK: can legislation turn rhetoric into reality?* Proceedings of European Council for an Energy Efficient Economy, Summer Study 2001, ECEEE.
- Jones, R. J. (1995). *Energy conservation issues in the UK*. Chelmsford, UK, Marine Marketing.
- Keeling, C. D. and T. P. Whorf (2004) Atmospheric CO₂ readings from sites in the SIO air sampling network. In *Trends: A compendium of data on global climate change*, Carbon Dioxide Information Analysis Centre, ed., Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee.
- Levett, R. (2004). "Quality of life eco-efficiency." *Energy and Environment* **15**(6): 1015-1026.
- Meyer, A. (2000). *Contraction and convergence: the global solution to climate change*. Totnes, UK, Green Books.
- ONS and NETCEN (2004). Carbon Dioxide Emissions by 93 Economic Sectors 1990 to 2002. Published on the web at: <http://www.statistics.gov.uk/statbase/ssdataset.asp?vlnk=5695&More=Y>.
- Owens, S. and R. Cowell (2002). *Land and limits: Interpreting sustainability in the planning process*. London, Routledge.
- Potter, S. (2004). "Transport tax reform and the environment." *Energy and Environment* **15**(6): 1093-1098.
- RCEP (2002). The environmental effects of civil aircraft in flight. London, Royal Commission on Environmental Pollution.
- Sustainable Development Commission (2005). Climate change programme review: the submission of the Sustainable Development Commission. London, Sustainable Development Commission.
- Wilhite, H. and L. Lutzenhiser (1997). *Social loading and sustainable consumption*. Proceedings of European Council for an Energy Efficient Economy, Summer Study 1997, Danish Energy Agency.