Carbon rationing, equity and energy efficiency

Tina Fawcett
Bartlett School of Graduate Studies, Faculty of the Built Environment
University College London, Gower Street
London WC1E 6BT, UK
t.fawcett@ucl.ac.uk

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Abstract

This paper examines the prospects for domestic carbon rationing and its implications for current energy policies.

Carbon taxation proposals at an EU level have been repeatedly delayed, and the present British government is committed to not raising national taxes on domestic energy. Carbon rationing is an alternative mechanism to limit carbon emissions from the domestic sector. In addition, the most promising basis for a global greenhouse gas control protocol to succeed Kyoto is 'contraction and convergence', which is based on eventual equal emission rights for everyone. Domestic carbon rationing would replicate this principle.

Questions of equity are crucial to political and public acceptance of carbon reductions. Would a policy of equal carbon allowances be seen as fair, given the disconnection between energy services and carbon emissions created both by efficient technology and renewable energy? Data on energy expenditure and use from different income groups and according to number of people per household in Britain are presented. The important differences between these groups are highlighted.

Evidence from the historic experience of rationing food in Britain is used to explore how notions of fairness can be negotiated via the design of a rationing scheme. Various existing proposals for domestic carbon rationing are presented and compared. The applicability of this evidence to other European countries is discussed.

A carbon rationing regime would necessitate a changed role for energy efficiency. Suggestions for re-thinking current policies and instruments in order to maximise their effectiveness under carbon rationing are presented and forward-looking approaches are proposed.

Introduction

Global climate change is the most serious environmental threat that human beings face. Unfortunately it is precisely the sort of problem we are bad at dealing with. It is a long-term threat with relatively uncertain consequences requiring action from everybody in the world. It is caused by the everyday way of life of all of us who use fossil fuels. The solutions involve considerable social and political change as well technological improvement. There are few simple answers. At the moment, little is being done compared with the scale of the threat and it is hard to envisage how this will change. Nevertheless, change it must and the ideas from the energy policy community should be key to helping bring about that change.

Both global and national moves are needed to achieve reductions of greenhouse gas emissions. This paper investigates a possible national framework for emission reductions, which would harmonise with the most promising proposal to reduce emissions globally. Firstly the theoretical reasons for supporting personal carbon rationing, with reference to international negotiations as well as national targets, are discussed. Then, the paper considers more practical issues. The main focus will be on the extent to which carbon rationing makes sense in terms of equity and a national energy policy. The practical discussion is based primarily around

Table 1. Domestic sector carbon dioxide emissions per household, UK.

	Emissions (tC/yr)	Index
Average stock UK (2000)	1.6	100
Average new (2002)	0.9	56
Average new + efficient lights and appliances	0.75	47
Target for average in 2050 (-60% UK)	0.52	32

Sources: Fawcett, Lane, & Boardman 2000, DETR 2000

the UK emissions which come from household energy use – and is broadened to consider the situation in other EU countries. This paper considers carbon (or carbon dioxide) emissions from fossil fuels – the most significant anthropogenic greenhouse gas. The principles developed for carbon emissions could be extended to the other greenhouse gases.

Carbon emissions and savings targets

At present in the UK, around half of national carbon emissions are the direct responsibility of individuals through their use of household energy and personal transport. This figure does not include emissions from international air travel, which would increase the proportion for which households are directly responsible. The other half of emissions are created by the industrial, agricultural and commercial sectors in order to satisfy the demands of householders for goods and services. This paper focuses on the 30% of emissions from household energy use (this figure includes the carbon emissions from electricity generation for households). If all fossil fuel carbon emissions in the economy are allocated on a per capita basis, then each UK citizen was responsible for 2.5 tC in 1999 (Marland, Boden, & Andres 2001), about two and a half times global average emissions.

The reduction needed before carbon dioxide emissions can be considered 'safe' is still under debate. The UK's Royal Commission on Environment and Pollution (RCEP 2000) suggested a 60% reduction in carbon emissions by 2050. This equates to emissions of around 1tC per person, assuming no significant population growth. Others consider this reduction too small, for example Hillman (1998) suggests we should look at a 90% reduction in the UK. However, using the 60% figure for illustration, Table 1 shows the current average carbon emissions per UK household and the RCEP target. Meeting the target would require that each household emit only 32% of 2000's average (there will be more households in 2050 than today, so each individual household has to save 68% to give a 60% reduction in total). A house built to 2002 building standards and using average amounts of energy for lights and appliances produces 56% of today's average emissions. If the new house were equipped with very efficient lights and appliances, the resultant emissions of 0.75 tC/yr would be 47% of the average. However this level of emissions is still almost 50% higher than the target for 2050. Thus even our most efficient (mainstream) housing is not meeting future standards. This demonstrates the scale of the challenge faced.

The global way ahead: contraction and convergence

The Kyoto agreement on greenhouse gas reduction is likely to deliver relatively modest savings. However, optimists (and realists?) see it as the first of a succession of treaties which will eventually deliver savings which will be sufficient to prevent dangerous climate change. Future treaties will need to involve all countries of the world, not just the developed countries currently committed to reductions under Kyoto.

A means of reaching a just global agreement on emission reductions called contraction and convergence (C&C) was first proposed by the Global Commons Institute in 1990 (Meyer 2000). C&C is founded on two fundamental principles: first, that the global emission of greenhouse gases must be progressively reduced, secondly, that global governance must be based on justice and fairness. C&C does not entail a particular concentration of greenhouse gases as being the safe limit, nor a time scale for reductions – this would be a matter for scientific judgement and political negotiation. However, in his book Meyer (2000:87) suggests illustrative figures of a global target maximum CO_2 concentrations of 400 ppm with convergence on a per capita emissions entitlement consistent with this to be completed by 2030.

C&C consists of:

- Contraction: An international agreement is reached on how much further the level of CO_2 can be allowed to rise before the changes in the climate it produces will become totally unacceptable. Once this limit has been agreed, it is possible to work out how quickly current global emissions must be cut back to reach this target. This cutting back is the contraction part of contraction and convergence.
- Convergence: Global convergence to equal per capita shares of this contraction, by an agreed year.

Global emissions trading would ease transition costs towards zero-emissions lifestyles and techniques. Those countries which were unable to live within their allocation would be able to buy more permits from countries which ran their economies in a more energy-frugal way. This feature would lead to a steady flow of purchasing power from countries that have used fossil energy to become rich to those still struggling to break out of poverty. C&C would thus not only shrink the gap between rich and poor but also encourage the South to develop along a low fossil-energy path (Meyer 2000:19).

Alternative approaches to global negotiations have been suggested, for example, they should be based on historic emissions of greenhouse gases, so that developed countries

would take full responsibility for their past emissions. However, C&C is considered by many to be the scheme most likely to succeed the current Kyoto agreement. For example, as mentioned above, the Royal Commission on Environmental Pollution has recommended that the UK should adopt a target for carbon dioxide emissions reduction of 60% from 1997 levels by 2050. This is based on C&C principles with the aim of ensuring that an upper limit of 550 ppm carbon dioxide in the atmosphere is not exceeded (this is around twice the level of carbon dioxide there was in the atmosphere pre-Industrial Revolution). This reduction target has been endorsed as achievable and necessary by many organisations, including the Environment Agency and the Carbon Trust, but it is not (yet) government policy.

Equity as a key issue for national schemes

This paper proposes that equity should also be the key to deciding how to reduce carbon emissions at a national level. Other criteria which could be used to decide between ideas are effectiveness and efficiency. Economic efficiency is, not surprisingly, usually chosen as key value by economists. As for international agreements, the focus on equity is for two types of reasons: principled and pragmatic.

The principle is of course the same as that used at an international level: reducing greenhouse gas emissions is a benefit needed by all the earth's people and equal rights to pollute are as applicable at national as at international level. Equity is fundamental to the enterprise of trying to limit climate change.

The pragmatic reason is that without equity (and perceived equity) there will be no public acceptance or political agreement to introduce the measures needed to significantly reduce carbon emissions. Meyer's argument (2000:20) works equally well at the national as international level: "The equality-of-access-to-emission-rights aspect of C&C is not there for idealistic reasons. It is pure pragmatism. It is the only approach likely to have any chance of success." To put it another way, in the words of an American housewife talking about food in the second world war: "rationing is good democracy" (Bentley 1998).

Claiming equity as the first priority nationally as well as internationally (after environmental effectiveness), leads to recommending equal per capita carbon allowances for personal energy use within the UK. This idea is known as carbon rationing and is explained in more detail in the following section.

Carbon rationing

This section summarises two different schemes which have already been proposed for carbon rationing, compares them and then elaborates on the type of carbon rationing scheme preferred by the author. The terms carbon ration and carbon allowance are used interchangeably.

PERSONAL CARBON RATIONS

Starkey & Fleming (1999) have developed a detailed scheme for national carbon rationing which they call a Domestic Tradable Quota (DTQ) system. DTQs would allow national authorities to take control over the rate at which fossil fuel consumption is reduced, while allocating the available resource fairly and maintaining price flexibility so that the economy can distribute it efficiently. The nation implementing the scheme sets an overall carbon budget that is reduced over time. The 'carbon units' making up this budget are issued to adults and organisations. All adults receive an equal and unconditional entitlement of carbon units; organisations acquire the units they need from a tender, a form of auction modelled on the issue of government debt. There is a national market in carbon units in which low users can sell their surplus and higher users can buy more.

Virtually all transactions could be carried out electronically, using the technologies and systems already in place for direct debit systems and credit cards. Starkey and Fleming claim that the scheme would be effective, equitable and efficient. In addition, the system would provide the framework for establishing carbon reduction as a proper objective of public policy, playing a central part in aligning social norms and values with individual responsibility for reducing carbon emissions. It would complement at national level the international contraction and convergence model for sharing carbon emission rights.

COLLECTIVE CARBON RATIONS

A scheme which could be characterised as offering collective responsibility, based on personal carbon rations was suggested by Fawcett, Lane, & Boardman (2000:75). This scheme was called Average Utility Carbon per Household, or AUCH. The national government would set sector targets for carbon reductions, and based on this would give energy utilities a reducing cap for emissions. Initial allocation of emissions permits to the utilities would be based on the number of customers, with separate allocation for gas and electricity use. The idea was that utilities could achieve lower average household emissions through investment in both lower carbon technologies (including renewable energy) and in reducing demand per household. Energy utilities were seen as a key actor, who already have some responsibility to save energy via existing UK legislation, and who have the technical knowledge and capability of investing to achieve carbon savings.

AUCH is based on the same principle as DTQs – that of equal emission allowances for individuals which reduce over time – but the location of responsibility for meeting the rationing targets is allocated to a different actor. The thinking behind AUCH emerged from research which demonstrated the limits individuals face in trying to reduce their emissions:

"In reality, consumers have restricted incomes and fuel choices, imperfect information, face limited choices in the retail environment, have to rely on the advice of professionals and, not unreasonably, have priorities other than energy and carbon efficiency. Consumers are people – bound into complex webs of social and cultural expectations that influence what is considered desirable, acceptable and normal. This may be very different from what is, in theory, economically justified and environmentally beneficial. In addition, retailers, manufacturers, installers, energy companies, architects and other all have an influence on what ends up in the home, and their business is not based around recommend-

ing low carbon solutions" (Fawcett, Lane, & Boardman 2000:41).

The major criticism of AUCH was that it offered no incentive to the consumer to reduce his or her own energy consumption / carbon emissions. Utility companies felt that they alone would not be able to reduce carbon emissions and should not be expected to do so.

PREFERRED SCHEME OF CARBON RATIONING

This paper is largely concerned with the principles behind carbon rationing, rather than with proposing a detailed description for a rationing scheme. However, without some description of how rationing might work, it can be difficult to engage with the idea. The carbon rationing envisaged here is along the same lines as Starkey and Flemming's DTQ scheme. Individuals would have an annual allowance for carbon for their direct fossil fuel consumption, i.e. home energy use and petrol and other transport fuels, which could be managed electronically. Carbon allowances would be tradable.

If the RCEP's target is adopted and applied pro-rata to domestic energy use, this would commit individuals to a reduction of almost 70% over the next fifty years – which equates to a reduction of about 2% of carbon emissions per year. It would probably be best to introduce carbon rationing with no annual reductions initially to give people time to understand and start adjusting to the new system.

Many social, technical and policy innovations would be needed to make it easier for people to live within their carbon rations. On the technical side, innovations could include 'smart meters' which informed people how much of their carbon ration for that year was left, which appliances were using most energy, how much carbon could be saved, for example, by reducing time spent in the shower, or by only heating bedrooms in the late evening. Alternatively, energy companies could install sophisticated carbon management systems in houses which took these decisions automatically. Possible policy innovations are discussed later in the paper. Energy companies, appliance manufacturers and others would have a role in enabling domestic carbon reductions, which would be facilitated by both demand and supply side changes to energy. The idea is not to punish people, it is to make it as easy and fair as possible for us all to achieve, over time, the necessary lower-carbon lifestyle.

Carbon taxes

Compared with the relative lack of interest in rationing, there has been considerable interest in carbon taxation. Indeed six European countries have already introduced carbon taxes (The Royal Society 2002:8) and the history of attempts to introduce an EU-wide carbon tax is given briefly below.

CARBON TAXES IN THE EU

Carbon and energy taxes have been frequently advocated by economists and international organisations as a policy instrument for reducing carbon dioxide emissions. In the practice of environmental policies an increasing number of Western European countries have implemented taxes based on the carbon or energy content of the energy products.

The idea of a carbon energy tax has had a long European history, beginning with a Commission-initiated research programme from 1979 to 1986 during which time the evidence on global warming was collected. By 1990, the tax was being promoted by the Commissioner for the Environment in international meetings (Haigh 1996). The tax was proposed by the Commission in 1992. However, there was much opposition to such a tax, due to worries about its regressive nature and its potentially damaging effect on international competitiveness. In addition, many member states believed they should be free to control their own tax levels. In 1994 the Council of Ministers determined that there would be no tax set at EC level.

However, that was not the end of the issue. In 1997 a new Directive on restructuring the community framework for taxation of energy products was proposed by the Commission. This has been under discussion since that time. The latest development is publication of a compromise proposal by the European Council in June 2002 (Council of the European Union 2002). As part of that proposal, domestic energy may be exempted from carbon taxation. There is also a long list of other situations where member states could apply exemptions. The timetable for decision has been set as the end of 2002.

DISCUSSION

Meyer (2000:54) identifies two major problems with carbon taxes. Firstly, they hit the poor in any country more harshly than the rich, since the less well off spend a greater proportion of their income on buying fuel. Secondly, their effectiveness varies according to the trade cycle – a tax rate that achieves its objective in limiting emissions in a period of strong economic growth will be much too harsh when that same economy is in recession. By contrast, rationing has the advantage of certainty of result, it is clear exactly what carbon savings will be made.

In addition, in the UK at present there would be great resistance to any form of taxation on household energy use. This is more than the usual resistance to additional taxes, it has a specific political history. This resistance is partly as a result of consciousness of the problems of the millions of people in 'fuel poverty', those people who already have difficulty affording adequate energy services, particularly winter heating. Domestic energy taxation is seen as inherently unfair. Taxation does not have the same moral basis as rationing, it allows those with higher incomes to pollute more as of right.

A recent report (The Royal Society 2002) considers the case for carbon taxes and other economic instruments, such as permit auctions, in reducing carbon dioxide emissions. The aim of the report is to make the case for economic instruments as opposed to environmental regulation through technology standards. The key benefit claimed for economic instruments is that they lower the cost of compliance. Interestingly, the report suggests that in economic terms there may be no argument against tradable carbon rations: "In principle, tradable permits achieve the same result as environmental taxes… In practice, there are several considerations that may favour one option over the other." (The Royal Society 2002:3) Most of the debate in the report is around the needs of industrial firms rather than individual house-

holders and the effect of introducing tradable permits (like DTQ) for householders, rather than carbon taxes, is not discussed. However, the implication seems to be that there are no economic grounds for favouring taxes compared with rations.

To summarise, compared with carbon taxation carbon rationing has the following advantages: clarity, certainty of result, equity for householders, likelihood of implementation, moral force.

Previous experience of rationing

The previous experience of rationing described relates to food during the second world war, as there has been no long term rationing of energy in Britain affecting the majority of the population. Comparison with food rationing is important, because food rationing affected many people in Britain (as well as many other countries) for over a decade – so the considerations and debates about this policy should be able to tell use something about the issues that carbon allowances would raise. Equity and fairness were key issues in second world war rationing.

FOOD RATIONING DURING THE SECOND WORLD WAR

During the second world war years, some degree of food control and rationing operated in almost every country in the world, from the richest agricultural countries like the USA and Australia to the poorest such as India and China (Burnett 1989). In this section the British experience of food rationing is briefly described.

In the course of the war civilian consumption of food, clothing and miscellaneous goods was reduced drastically as economic resources were directed towards the war effort. The food rationing schemes were concerned mainly with protein foods, milk and fats, the need for which varies less between different sections of the population than it does for other nutritive elements. The British scheme rationed meat, bacon, cheese, fats, sugar and preserves in fixed quantities per head. The principle of a flat-rate ration for all, which ignored the diverse needs of heavy workers at one extreme and small children at the other, was justifiable since only a fraction of all foodstuffs were rationed. In addition, it was recognised that certain categories of the population had special nutritional requirements, and therefore other schemes were super-imposed on this common basis. For example, there were schemes which provided additional proteins, vitamins and minerals to children of pre-school age, nursing and pregnant mothers (Burnett 1989:292).

Rationing, coupled with subsidies and price controls, promoted greater social equality, and consumption became more equal in contrast with the intense inequalities that existed previously. The fair shares policy was critical in maintaining morale at a time when the share of personal consumption in national expenditure fell from about four-fifths in 1938 to about half in 1944 while resources devoted to the war effort increased from 7 per cent to half the total (Zweiniger-Bargielowska 2000:10).

Despite difficulties, contemporary opinion polls showed that rationing and food control were on the whole popular and discontent was eclipsed by general satisfaction. Ultimately food morale was maintained during the war, even though two-thirds thought that food quality was worse in 1944 than before the war, because people accepted the necessity of sacrifice for the duration (Zweiniger-Bargielowska 2000:79).

The British experience with food rationing is that the chosen scheme was seen as fair and retained public support up to and beyond the end of the war. It was effective: overall nutrition was improved from the period before the scheme started. Rationing operated alongside policies on price control, which ensured that people could afford to buy their ration of food. There were also large-scale governmental persuasion and information campaigns explaining the reason for rationing and advising people on how to cope on their rations.

COMPARISON WITH CARBON RATIONING

There are both similarities and differences between food and carbon rationing. One similarity is that everyone needs both food and energy to survive (the key is clearly to break the link between carbon emissions and energy use that currently exists). In some ways, carbon rationing would be less prescriptive and intrusive in everyday life than food rationing, people could select from many lifestyle and technical adjustments in order to reduce their personal carbon emissions. Having said that, fossil fuel energy use underpins most aspects of modern life, including growing and importing food, so making the transition to a lower carbon society is clearly an immense task.

The reason for introducing food rationing was to ensure the population remained well-fed at a time of national crisis and restricted food supplies. If society had not accepted rationing, and associated price controls, the effect would probably have been very many people going hungry – an unacceptable outcome, and one which would have been immediately experienced by the population. In the case of climate change, no such immediate and personal effects of increasing carbon emissions would be felt. So the motivation for the UK undertaking carbon rationing as a whole is different, and the personal connection with the benefits of carbon rationing would be less immediate. There is also the obvious contrast that food rationing was limited in time, although people did not know how long that time would be. Restrictions on carbon emissions to the atmosphere need to be permanent.

Food rationing is in theory equitable in that each person (of a particular age / gender / activity level) needs about the same amount of food to stay healthy. However, depending on the number of people living together and the efficiency of their home and equipment, similar people can require very varied amounts of energy. Having said that, inequities were recognised as existing in the food rationing system, even after the additional allowances given to special groups: "To some extent 'rationing bore most heavily on those living alone [and] least upon those families whose capacity for mutual adjustment was greatest'. However, the situation was complicated by the fact that single people frequently had more money to spend on unrationed foods and whereas the system advantaged families with young children, flat-rate rations were not generous with regard to adolescent needs" (Zweiniger-Bargielowska 2000:80). Perfect equity is not needed for a system to be seen as fair.

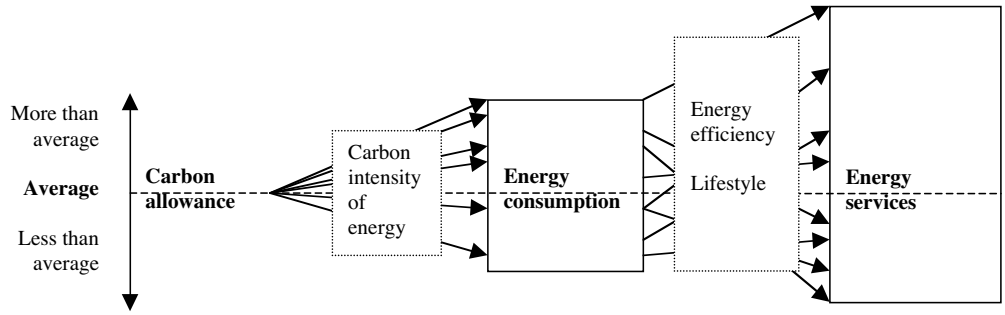

Figure 1. *An average carbon allowance can lead to very different levels of energy consumption and energy services.*

On a more practical note, administration of carbon rationing would also be rather simpler than for food as there are few sellers of gas and electricity and other fuels compared with the tens of thousands of food retailers. There should be little room for a black market to develop given that flows of fossil fuels are already very well recorded and tightly regulated in our economy. As with the food ration, some sources of energy would be 'off ration'. For example, green electricity, household level photo-voltaics (PV), solar water heating and wood burning stoves would be carbon emissions-free energy. During the war, food rationing affected producers as well as consumers – for example, cheese production was taken from individual farms into factories to make it a more efficient (if less tasty) process. Similarly with carbon rationing, producers of energy would be expected to respond, by offering lower carbon energy sources, good carbon saving advice, etc.

Is rationing equitable in practice?

Having said that a rationing scheme is favoured for reasons of equity, it is important to discuss whether rationing would be equitable in practice. The case for carbon rationing is that giving each person equal rights to emit carbon seems the most equitable possible scheme. The case against is stated clearly in a Ministry of Food second world war memorandum, quoted in (Zweiniger-Bargielowska 2000:79), "Rationing is essentially inequitable; it provides the same quantity of an article for each person without any consideration of their needs or habits or of their capacity to secure alternatives".

Neither equal carbon emissions nor equal energy consumption allowances equate to equal energy services. Efficient end-use equipment, well insulated (and smaller) homes, lower carbon energy sources and renewable energy all create a disconnection between carbon emissions and energy services (Figure 1). Of course it is this disconnection that offers people positive opportunities to reduce their carbon emissions without sacrificing energy services which are important to them. However, it also means that equitably distributed carbon allowances could result in very inequitable levels of energy services.

There is no simple index of energy services – it consists of a wide range of services including washed clothes, warm rooms, mowed lawns, hours of TV watched and refrigerated food. People do not have equal wishes or needs for these services and the idea of 'equality of energy services' may not be a useful one. Describing a minimum level of energy services which people "need" is probably a hopeless task. As Dobson (1995:90) notes, building a theory of need is notoriously difficult. However, some services, such as a minimum internal house temperature are required by all people to remain comfortable and healthy and it is important that all are able to achieve these under carbon rationing. Or at least that carbon rationing does not worsen existing inequality. The concept of affordable warmth and its converse, fuel poverty, is well grounded in UK research and public policy and could be used as the key indicator of fairness under carbon rationing.

Since there is to be trading, people who don't have sufficient carbon rations to meet their desired lifestyle can buy more if they can afford them. Those without sufficient income could be helped either to reduce their need for carbon (ideally) or given more rations from the pool of those sold back to the government.

People will not have the same capability of achieving off-ration energy supplies or increasing their energy efficiency. For example many properties would not have a suitable roof for installing solar water heating. Other households might have the right sort of roof, but no money to buy a solar water heater. Householders who do not own their own roofs (and homes) would not have the same freedom to add a solar water heater – they would have to rely on their landlords to do so. Thus, there is no guarantee that all households could reasonably reduce their carbon emissions to the same level: this is a consequence of variations in housing stock, knowledge, wealth and tenancy, variations which will no doubt persist through time. It will be the role of the government to decide to what extent it supports those with a lower capacity to reduce their emissions, and how this support is offered.

Current carbon emissions

How do carbon emissions currently vary by household type in the UK? Evidence below examines how energy use per person varies depending on income and number of people in the household. Energy use is used as an indicator for carbon emissions. Around 80% of UK households use gas as their space and water heating fuel. As there is relatively little variation in the types of fuel used for heating and hot water (the dominant residential uses of fuel) and other requirements are almost universally met via electricity, delivered energy use acts as a reasonable proxy for carbon emissions.

ENERGY EXPENDITURE AND INCOME

There is no direct, nationally representative data available on energy consumption by income group, however, energy expenditure by income group is available. Expenditure on

Table 2. Household energy expenditure, UK, 2001-02.

Household income quintile	Household energy expenditure (£ per week)	Household energy expenditure index (quintile 1 = 100)	Energy as a % of total expenditure	Persons per household	Personal energy expenditure index (quintile 1 = 100)
1	8.75	100	5.9	1.5	100
2	10.35	118	4.2	2.0	89
3	11.20	128	3.1	2.5	78
4	12.95	148	2.6	2.8	79
5	15.25	174	2.0	3.1	84

Source: Based on ONS 2003

Table 3. Scale effects of household size on the use of energy (one-person household = 100), England, 1996.

Household size	Electricity per household	Gas per household	Electricity per person	Electricity per person
1	100	100	100	100
2	137	129	69	65
3	165	142	55	47
4	180	156	45	39
5	192	175	38	35

Source: Based on Fawcett, Lane, & Boardman 2000

energy is not a perfect proxy for energy use because, for example, there is evidence that poorer people tend to pay more per kWh than the better off (Boardman & Fawcett 2002), nevertheless it is the best currently available evidence for the UK. Energy expenditure on all forms of household fuel (gas, electricity, oil and solid fuel) is shown by income quintile (Table 2), where quintile 1 is the 20% of the population with the lowest income and quintile 5 is the richest 20%.

Expenditure on energy increases as household income increases; the richest group spend 80% more on energy than the poorest. However as income increases, the percentage that energy represents of the household budget falls – so that the poorest group are spending almost three times as much of their income on household energy as the richest. The number of people per household increases in parallel to household income, thus, when energy expenditure is compared on a per person basis, it is the poorest who spend most. At first glance, this is a surprising result.

Assuming that expenditure maps reasonably well onto energy use and carbon dioxide emissions, this means that a carbon rationing scheme based on personal allowances would have a greater impact on the poor. The effect of smaller household sizes on energy consumption is discussed in more detail below, followed by a general discussion of the implications of these patterns of consumption for carbon rationing and equity.

CARBON EMISSIONS AND HOUSEHOLD SIZE

As Table 3 illustrates, somebody in a one-person household, regardless of income, uses around twice as much electricity and gas and therefore produces twice the carbon emissions as somebody in a three-person household. Unlike food consumption, or water use, energy consumption is influenced strongly by household size. People in one-person households would have to do considerably more in terms of low carbon energy sources and efficient equipment to have the same energy services within their carbon allowance than would a person with the same lifestyle in a larger household.

Average household size in Britain in 2000 was 2.3 persons, and 32% of households contained just one person (National Statistics 2003). The proportion of one person households has increased steadily over the decades (from 17% in 1971) and is expected to continue to grow. People move between different household sizes, becoming one-person households at some points in their lives, without necessarily moving house. Given the large number of one person households – of many different types from low-income, widowed elderly people to affluent young professionals – the problems they would face under personal carbon rationing would have to be acknowledged.

DISCUSSION

The fact that poorer households are coincident with smaller households is the reason why expenditure on energy is greater per person in poorer homes. Assuming expenditure maps reasonably well onto carbon emissions, this would mean that carbon rationing could result in the poorer, who are most likely to be in fuel poverty and receiving inadequate energy services, having to reduce consumption more than the richer. Thus a scheme which is equitable in theory, seems to result in an inequitable outcome (although not as inequitable as carbon taxation). A good way of overcoming this would be to combine a carbon ration for household energy with transport fuel because expenditure on household and transport energy combined rises steadily on a personal and household basis with increase in household income (ONS 2003). Combining personal transport and household energy use in a single scheme would also give people more flexibility in responding to carbon restrictions. Thus, it seems considering household energy use in isolation when debating schemes for carbon rationing may not be the best approach.

EU

Carbon emissions per capita across the whole economy vary considerably between EU countries. The highest emissions are from Luxembourg at 5.07 tC per capita, Germany's are 2.63 tC, France's are 1.66 tC and Sweden has the lowest

emissions in the EU at 1.43 tC (figures for fossil fuel emissions, 1999 – Marland, Boden and Andres 2001). All economies emit above the world average of 1.11 tC per capita and above the RCEP's target by 2050 of 1 tC per capita.

Carbon emission figures for the domestic sector alone are not readily available, however information on delivered energy and the sources of energy used in each country indicates that carbon emissions for this sector would vary considerably. Both energy use and the carbon intensity of the energy, the factors which determine carbon emissions, differ between countries. The delivered energy consumption in 1996/7 for most European countries varied between 17 000 and 26 000 kWh per household per annum, with the exception of Greece, Spain and Portugal, where consumption was approximately 10 000 kWh (Griffin and Fawcett, 2000). In terms of carbon intensity, there are considerable differences in the carbon burden of electricity produced in each country, depending on the energy source. Countries with high proportions of nuclear and/or hydro electricity emit much less carbon dioxide per kWh than countries using large amounts of coal to generate electricity. The carbon intensity of fuels used for space heating also varies. Some countries, such as Sweden, make extensive use of electricity for heating, whereas in the Netherlands gas space and water heating dominate, and in Ireland there is a mixture of oil, solid fuel and natural gas. The combination of these differing energy use and carbon intensity patterns will result in differing domestic carbon emissions.

These differing emissions across the EU do not alter the arguments in principle made in this paper about equal emissions rights per person. Although the EU is currently 'burden sharing' for Kyoto reductions, it is unclear whether it would wish to continue to do so in the longer term, and whether that would be acceptable in C&C negotiations based on global equity. It is not clear that there should be a specific EU dimension to carbon rationing, or that a single EU scheme would be more effective or more acceptable to public option than separate schemes in each country. On the other hand, there is an increasing EU dimension to energy policy and a trial EU scheme on trading of (non-domestic sector) carbon emissions has been agreed. If, in future, governments are prioritising national carbon rationing schemes, this would lead to re-examining the role of the EU in energy efficiency policies such as Energy Labels and minimum standards.

In terms of energy use and equity, it appears that some of the issues which were raised for the UK may be common across the EU. Analysis of 1988 energy expenditure data for 12 EU countries (Koehler, Luhmann & Wadeskog 1999) showed that energy costs form a universally greater proportion of the expenditure of low income than high income households. For most countries, the budget portion spent on energy decreased from about 40-50% above the average for the lowest expenditure group to roughly 60-70% of the average for the highest expenditure group. However, expenditure across income groups varies to a greater extent in some countries than others, so that equity concerns may also vary between countries. Household size data by income group was not available, so it was not possible to repeat the UK analysis on energy expenditure per person as opposed to per household.

In addition to spending more of their income on energy, lower income households may also make use of more carbon intensive fuels, such as solid fuel, putting them at a further disadvantage. For example, in Ireland lower income households tend to purchase more carbon-intensive solid fuels (Griffin and Fawcett, 2000). This was previously the case in the UK, but is much less so now due to widespread use of natural gas. A link between lower income households and higher carbon fuels will not necessarily the case in other European countries, it depends very much on the choice of fuels available, their relative costs and the heating equipment available in people's homes. Thus understanding how carbon rationing would interact with equity concerns in practice has to be considered separately for each country.

This brief consideration of the European aspect of carbon rationing has raised more questions than it has answered. The principle of carbon rationing is the same across all EU countries, however, the practical outcome of a rationing scheme in terms of equity may be very different per country depending on the fuels used, patterns of income and household size. Given that the poorest spend more of their income on energy in all countries, and that carbon taxation would therefore be regressive, carbon rationing should be a more equitable and attractive option. However, concerns about equity may vary between countries, and other considerations may dominate the choice of policy instrument. Finally, given these differences of carbon emissions and equity concerns between countries, it is open to question whether a European-wide carbon allowance scheme would work, and what its advantages might be compared with individual nation state schemes.

Carbon rationing and energy policy

Carbon rationing is not explicitly an energy policy, however it links very closely with what people can do with energy as 96% of UK carbon dioxide emissions derive from the combustion of fossil fuel (The Royal Society 2002:vii). Carbon rationing would be the most important influence on energy policy, both on the demand and supply side. Only demand-side policy is discussed here.

ENERGY EFFICIENCY

There is no doubt that energy efficiency has the potential to provide significant carbon and energy savings. A recent EU-wide study (Anon 2001) suggested measures which should reduce greenhouse gas emissions from 1990/95 to 2010 by 16% across all sectors of the economy. Other studies have come up with similar or more ambitious figures. Thus, energy efficiency will be a significant contributor to lowering carbon emissions, but the evidence (particularly evidence of the change in household energy use over recent decades) strongly suggests it will not be sufficient given the scale of change required. We are far too good at inventing new ways to use energy (digital TV) and ways of using more energy (buying ever larger TVs), and not nearly good enough at implementing the energy efficiency schemes suggested by diligent researchers.

One of virtues of energy efficiency as an idea is that it focuses on win-win situations. It can be accepted as a good thing by economists, engineers and environmentalists alike.

However, energy efficiency should only be seen as a tool: it should not be a goal in its own right. Efficiency policy can be used to ignore or side-step the moral dimension to consumption, but in doing so it is leading discussion away from the important challenges we have to face. Failure to acknowledge the limits of efficiency may also encourage the view that there can be a wholly technical solution to the carbon emissions problem can be found. There is no evidence that this is likely to be the case. By hoping for a technical fix, we may be delaying the discussion of the necessary social and political adaptation to new ways of life to reduce carbon emissions. Finally, under carbon rationing, energy efficiency may lose some of its utility in energy policy. From a carbon emissions point of view, it is of little importance whether solar hot water is used efficiently.

CARBON RATIONS AND EXISTING POLICIES

What would carbon rations mean for existing policies? If the responsibility for choices on carbon are being given to the consumer, then the level of information and education on carbon issues will have to increase drastically. We could look at the scale of education and information provided on food rationing in the second world war to see how to proceed. People weren't just given food rations and expected to adjust. There was a comprehensive information campaign using radio, magazines, leaflets, posters and so on giving recipes for the new types of food (such as powdered egg), suggesting how to economise with food while still providing healthy meals and persuading people to 'dig for victory' and grow their own vegetables. Enabling people to live well on food rations was a key government aim and taking pride in doing so became part of the national culture.

Under carbon rationing, information at the point of purchase would become even more important – people would need to know the carbon implications of buying a new piece of energy-using equipment. Carbon rations would fit much better with energy labels based on absolute consumption rather than relative efficiency. A small, less efficient fridge might be a better choice than a larger, more efficient one. Carbon rationing might work against industry agreements, currently used in some consumer electronics products sectors, which guarantee average energy efficiency improvements across the product range. People may demand to know the emissions from their particular gadget. Houses, old and new, would need to be labelled with average carbon emissions per year at the point of purchase or rental. Energy bills would become key providers of information, not only on costs but also on how much carbon allowance the householder had used up. Labelling of electricity, currently an issue under discussion in Europe, would also become important. These are just some of the many changes in policy which may be required in a carbon-restricted society.

Discussion

CARBON RATIONING AND EQUITY

Is there a realistic alternative but to have an 'equal shares' policy of carbon emissions for individuals? Despite the problems which have been shown for one-person and poorer households, an equal per capita allowance still seems the most transparent, fair and publicly acceptable scheme. The key to achieving equity in practice may lie in deciding which forms of energy are included in the ration; by including transport and household energy together the poorer and single-person households would no longer be automatically disadvantaged. At an international level, Meyer (2000:83) argues that you can't have special cases for climate emissions even for cold countries – as every country would claim to be a special case and negotiations would never be concluded. This may also be true at a national level for the claims of different groups.

However, equal allowances could be supplemented by some additional allowances for certain classes of people. During the war, manual workers in certain industries received extra rations in acknowledgement of their greater nutritional needs. This could be replicated in carbon rationing without undermining the essential principle of equity if the number of special cases was small and the grounds for special treatment generally agreed. However, in the case of carbon rationing it would make far more sense for the government to subsidise permanent efficiency / renewable energy measures for certain classes of people rather than grant them extra allowances.

PUBLIC ACCEPTABILITY

Introducing carbon allowances is unlikely to be easy or universally popular. Carbon rationing would not work unless people were committed to reducing their carbon emissions. However, this applies equally to the alternative of carbon taxation on the scale required to make significant savings. In addition, introducing personal carbon rationing would have to be undertaken in parallel with carbon reduction measures in the commercial and industrial sector – such measures would doubtless face a great deal of resistance.

Indeed, it is hard to imagine carbon allowances being introduced given today's political and social priorities. However significant carbon savings are not going to be made if the world continues in a 'business as usual' mode. If we are serious about preventing serious climate change, there is no choice but to challenge the status quo in a fundamental way.

TIME SCALE

It might be thought too early to begin discussing personal carbon allowances, when the fate of international negotiations after the Kyoto treaty is so uncertain. However, a European country could introduce carbon rationing now for domestic energy and/or personal transport as part of its programme to meet Kyoto commitments. The UK would be a suitable candidate to try this given the extreme political sensitivity and public resistance to any form of tax on household energy use. Starting carbon rationing now, prior to the next international agreement, would also help get the mechanisms in place before really serious reductions need to be made.

More immediately, should a medium-term (10+ years) vision of carbon rationing affect policies being designed today? As suggested earlier, energy efficiency policies should be re-oriented towards carbon conservation as their primary goal. This can begin immediately.

WHAT RESEARCH NEXT?

Clearly, detailed thinking about carbon allowances is at an early stage. Research on the following topics should help elucidate some of the issues raised in this paper:

- More detailed investigation into the links between household income and carbon emissions from household and personal energy use.
- Understand in more detail the energy consumption of one-person households. Is this chiefly a function of house size, i.e. are their houses about the same size as those of multi-person households, or is it because their energy 'fixed costs' cannot be shared across several people? In addition, how much variation does the national average figure hide?
- Estimate the rate of carbon taxes which would have to be levied to achieve 60% energy savings in the domestic sector. This would be a useful comparison with carbon rationing.
- Research more fully the implications for equity of a combined ration for household and transport energy use.

Conclusions

Equity is the only credible basis on which to focus negotiations for international carbon emissions reduction. It is also the right basis on which to deal with the half of carbon emissions in the UK for which individuals are directly responsible.

On average in the UK, richer households use more household energy, and the poor less. However, on a per capita basis, it appears to be the poor, who live in much smaller household groups, who use more energy. Thus equal personal carbon allowances for household energy alone would be likely to disadvantage the poor, as well as single-person households. By combining a personal allowance for household and transport energy, this problem should be avoided.

Previous experience with food demonstrates that an effective rationing scheme can be accepted as fair and necessary, whilst remaining simple and transparent. Replicating this sort of success in carbon rationing would not be easy, but it should be possible.

Energy efficiency is a powerful tool to enable carbon savings, but it should no longer be a policy goal in its own right. If we are to prevent dangerous climate change, we cannot avoid the necessity of accepting limits on our consumption of fossil fuels; carbon rationing is a promising mechanism for imposing limits fairly.

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