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Trialling personal carbon allowances

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1. Foreword

When we wrote A Rough Guide to Individual Carbon Trading for Defra in late 2006, we cautioned strongly against rushing to undertake a ‘pilot’ of personal carbon allowances (PCAs).

At the time there had been semi-serious talk of the ‘annexing the Isle of Wight’ and running a pilot mandatory PCAs scheme for its population to ‘see if, and how, it would work’. This seemed to us to be both a politically tempting proposition (particularly for anyone wanting to be seen to be ‘taking the initiative’) and a dangerously premature experiment with a concept which still had basic operational design questions outstanding.

We therefore posed the challenge: What would we be trying to achieve with a pilot or trial? Which questions will it answer?

Fortunately, at about the same time, the Lower Carbon Futures team at University of Oxford’s Environmental Change Institute set about responding to this challenge.

The result is this welcome report, clarifying what aspects of PCAs it would make sense to trial and how this might be done. Crucially, it addresses the research questions which such trials (and potentially only such trials) can answer.

As we know from the deliberations forming part of this study, it proves easy to get hung up on whether to label something a ‘pilot’, a ‘trial’ or a ‘simulation exercise’. The important contribution made here is to cut through this and describe in detail what it actually makes sense to do now as an academically robust exercise in furthering understanding of PCAs.

Simon Roberts
Chief Executive
Centre for Sustainable Energy

2. Executive Summary

A Personal Carbon Allowance (PCA) scheme is a new policy framework proposed to significantly reduce carbon emissions by establishing a “cap and trade” system for the carbon emissions produced by individuals through home energy and travel use. The PCA concept is rising up the policy agenda and has attracted high-level ministerial interest. However, there is currently insufficient evidence to decide whether introducing a PCA scheme would be an effective policy framework for achieving significant carbon emission reductions. Some of the key concerns about the policy are its perceived lack of social and political acceptability.

The Demand Reduction theme of the UK Energy Research Centre, supported by funding from the Esmée Fairbairn Foundation, has undertaken a scoping study to investigate the value and feasibility of trialling as a research method to advance understanding of PCA. In order to make use of existing knowledge, a wide range of experts, from academics to practitioners, has been consulted during this study, both individually and in workshop settings. Over thirty different experts have been engaged in discussions about PCA trials.

For this report, ‘trial’ means a real world experiment that as closely as possible replicates a real PCA scheme, on a small scale and for a limited time. Inevitably a trial of a very ambitious policy such a PCA, which relies on voluntary participation, cannot fully replicate the conditions of the real scheme. A trial will best be able to replicate the personal responsibility for and feedback on carbon emissions aspects of the policy, but will replicate the financial impacts on individuals less well.

A PCA trial would have several research functions. It would:

- investigate participants’ opinions of PCA, based on their experience of living with the concept for a year. This aspect of a trial would provide valuable insights into the potential social acceptability of the policy;
- monitor the effectiveness of PCA in motivating attitudinal and behavioural change, and investigate how these varied with economic and personal circumstances;
- seek to understand which aspect of PCA motivated any behavioural or attitudinal change, e.g. whether feedback, personal responsibility for carbon emissions or the simulated economic consequences were most important;
- test some of the detailed rules of PCA, e.g. allocation of partial allowances to children, both in terms of their effects, and participants’ views of them;
- demonstrate, if positive outcomes emerge from the trial, that PCA is a policy worthy of serious consideration. Conversely, the trial could show that at present this policy would not be likely to appeal to or motivate the UK public.

While there is no doubt that running a trial would be a complex and demanding research task, this study concludes it could provide valuable and unique insights into PCA.

The design of PCA trials is discussed in detail, covering topics including: the boundaries of the carbon allowance; the length of a trial; how to include carbon trading; sample selection; methods of data collection; and recruitment and retention of participants. Based on this work, a template for running

a PCA trial is proposed. The template should ensure key components of the policy are tested in a trial.

Using the template, three different trial designs are outlined: PCA Basic, PCA Community and PCA Comparator. PCA Basic – as the name suggests – is the most modest trial in terms of participant numbers and costs that we can envisage which would answer the key research questions. PCA Community works with particular communities and greater participant numbers to answer the same questions within specific groups of the population. PCA Comparator broadens the research scope to compare PCA with other possible carbon reduction policies. Approximate costings of the trials suggest they range from £500,000 for PCA Basic to £950,000 for PCA Comparator. The trials would take between two and half and three years from initiation to final report.

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3. Introduction

New solutions are needed in order to tackle climate change at the UK and international level because all the evidence is that existing approaches are not working. The UK's carbon dioxide emissions, excluding international aviation, have risen by 2% over the past ten years (DEFRA 2007). If international aviation were included, national emissions would show a much stronger upward trend. Globally, atmospheric concentrations of carbon dioxide continue to rise, and stood at 379 ppm in 2005, with emissions from fossil fuel usage rising at 3% per year since 1999 (IPCC 2007).

One radical new potential solution, a personal carbon allowances scheme (PCA), proposes a cap-and-trade system in which emissions rights are allocated to individual energy end-users. UKERC is researching a model of PCA which would cover all the direct energy used by individuals within their household and for personal travel. This would account for up to half of the carbon emissions from energy use in the UK (where international air travel is included). Every time a person paid an energy bill, filled up the car with fuel or bought a flight, they would have to surrender carbon 'credits' from their account, or pay the additional cost of buying carbon credits at the market price. People would be allocated an equal per capita allowance, which would reduce annually at the rate necessary to meet long-term emissions reduction targets. The PCA scheme does not include the other half of emissions within the economy, which are generated by organisations, for which a parallel carbon capping and reduction system would also be required. This economy-wide "cap and trade" emission scheme would incentivise the transition to a low carbon energy system. A cap and trade system already exists for much of the business sector in the form of the EU Emissions Trading Scheme.

PCA has the potential to reduce carbon emissions in an equitable, efficient and effective way. It is based

on the same principle of equity as that underpinning the international carbon reduction proposal 'contraction and convergence' (Meyer 2000), i.e. that everyone has an equal right to emit carbon. By allowing trading, the idea is that people who live low carbon lives can sell their spare allowances to those with higher emissions. A market price for carbon will emerge and higher carbon lifestyles will cost more than they currently do. The equal shares will not require that everyone emits equally – instead people will have choice and can adapt to a lower carbon society at a slower pace by buying additional allowances. This allocation system should be economically efficient as it will encourage lower cost carbon savings to be made first (although this is only wholly true if a 'perfect market' exists, which is not the case in reality). Because PCA will have a firm cap, national carbon emissions from these sectors of the economy cannot be exceeded.

In addition to these advantages, it is possible that PCA will inspire social cohesion around national carbon reduction targets, and will have a positive psychological effect beyond the financial incentive created by the tradable allowances. The moral basis of a PCA scheme is quite different from carbon taxation: it puts individual responsibility for carbon emissions at the centre of policy and engages citizens directly in emissions reductions in their own lives. This too could prove powerful in changing behaviour and accelerating the move to a lower carbon society.

There are other policies which could be used to provide a carbon reduction regime. Chief among these are carbon taxation – of various designs – and upstream capping and trading. Earlier research work has investigated and compared taxation with PCA (Keay-Bright and Fawcett 2005). Arguments in favour of PCA included its effectiveness, equity, distributional impacts and certainty, in principle, of delivering savings.

To date, PCA and related policy ideas have been primarily investigated within a UK context. There is very little, if any, non-UK literature to draw upon. Although some research is now being planned or undertaken in other EU countries, this is at a very early stage. Therefore, this report can only draw on UK experience.

There has been some initial research on the variations of carbon emissions within the UK population, and therefore what the impact of PCA could be. A key study demonstrated that on average emissions rise with income, but that there is also huge variation of emissions within each income decile (Ekins and Dresner 2004). This study of necessity used proxy expenditure data to estimate carbon emissions in different income deciles, which was particularly problematic when it came to air travel. The methodology used probably resulted in an underestimate of the amount of air travel undertaken by those in the higher income deciles (Dresner and Ekins 2004), and may therefore have underestimated the degree to which carbon emissions rise with income. This study also looked at the distributional impacts of PCA compared with various carbon taxation proposals, and demonstrated that PCA could be more progressive than taxation, i.e. fewer people in the lowest income groups would be worse off.

Recent work carried out by a UKERC researcher, calculated the carbon emissions from all personal travel of several hundred Oxfordshire households (Brand 2006), including travel by private vehicles, public transport and domestic/international air. Emissions from household energy use were not included in this study. Two results stood out. The first was that air travel dominated emissions at 70% of the average individual's travel emissions. This is considerably higher than shown in national statistics, and may be explained by a combination of factors including accounting methods, calculation

methodologies, and the easy access of Oxfordshire residents to international airports. Secondly, the data showed huge variations in personal emissions. The top tenth of emitters were responsible for 43% of total sample emissions, while the lowest tenth were responsible for just 1%. This indicates that PCA will have very different effects on different people, depending on their current carbon emissions, and of course their willingness and capacity to change. While existing research offers valuable insights, many questions about who would be affected by PCA and how they would respond remain unanswered.

Very limited research work has been carried out on attitudes to PCA. In the most comprehensive study to date, a small number of focus groups was run in 2005 in order to explore people's reactions to PCA in comparison with carbon taxation (Low 2005). The aim was to begin to determine whether, and in what circumstances, individual members of the public find the proposal acceptable. The focus groups were segmented into two broad categories: car-owners and the environmentally-conscious. These groups were chosen because they might be expected to have contrasting reactions to PCA. Two focus groups of each category were conducted.

Low found that participants were able to grasp the PCA proposal relatively quickly, and indeed were keen to explore the ins and outs of the scheme, asking some very perceptive questions about how PCA would work in practice. The three broad attitudinal groupings which emerged in relation to PCA were (a) those lacking in enthusiasm for either PCA or a carbon tax, (b) those with a preference for a carbon tax over PCA and (c) those who embraced PCA with enthusiasm. Overall, the car-owners groups tended to hold one of the first two attitudes, and on balance the environmentally-conscious groups inclined more to favour PCA

over carbon taxation. The key factors affecting participants' attitudes to PCA were their beliefs about the relative importance of the role of the state and the rights of the individual, and their opinions on the equity, practicality, environmental effectiveness and negative aspects of the PCA scheme. This research suggests that PCA could be acceptable to people who do not believe that the rights of the individual outweigh the need for the state to intervene to reduce personal CO₂ emissions. The results also suggest that there could be a lively public debate around PCA if the proposal were widely publicised and that the tenor of that debate could influence people's attitudes. Low's research revealed very useful insights which could be further explored through additional focus group or interview work, and which can help shape the design of any PCA trials.

If PCA were to be introduced, it would not be a stand-alone policy. It would simply form the umbrella mechanism within which a wide range of other policies would operate (Hillman and Fawcett 2004). Product policy using the full range of market transformation tools (regulations, incentives, information, voluntary agreements etc.) would still be needed to encourage more efficient lights and appliances into the market. New and existing housing energy efficiency and carbon emissions standards would continue to be tightened. Greater take-up of household-level renewable technologies would be supported. All these policies could work together with PCA or other mechanisms to reduce carbon emissions in the domestic sector by 60% by 2050 (Kierstead and Boardman 2005). Transport and planning policy would also need to find more effective ways of encouraging the use of lower carbon modes and, eventually, lower mobility lifestyles. Not only would these policies enable and encourage people to live lower carbon lives, they could also be used more comprehensively in advance of PCA to broaden the low carbon options available.

There is increasing interest in the idea of PCA within government and wider society. The previous Secretary for the Environment, David Miliband, has made clear his interest in PCA (Miliband 2006) and a Defra (Department of Environment, Food and Rural Affairs) programme of research is being designed to develop knowledge in this area. The House of Commons Environmental Audit Select Committee held an inquiry into personal carbon trading in June / July 2007, which is expected to report later in the year. In addition, there is growing grassroots movement called the Carbon Rationing Action Group (CRAG) network, which started in 2005. Currently, there are more than thirty groups nation-wide experimenting and demonstrating how a PCA scheme might work. A number of organisations are also in the early stages of trying out versions of PCA with their staff and supporters.

Despite the increasing public and political interest in personal carbon allowances and trading, it is a subject which is very much under-researched, with few active individual researchers or groups. The key individuals and organisations involved, in addition to UKERC, are the Tyndall Centre for Climate Change Research, David Fleming and the Royal Society for Arts (RSA). Researchers from other organisations, including the Centre for Sustainable Energy (CSE) and the Policy Studies Institute (PSI), and Mayer Hillman have also made important contributions to knowledge. Nevertheless, there are only a handful of people spending a significant proportion of their time researching this topic – probably no more than the equivalent of three or four full-time researchers in total, including those within UKERC.

Within UKERC an initial 'route map' for research on PCA has been developed (Fawcett 2005). This outlined the need to undertake detailed research which addresses the philosophical, political, social, economic, technical and practical aspects of the adoption and implementation of PCA in the UK.

Following this, in 2006 UKERC held a workshop with researchers and government civil servants from a variety of departments in order to identify research priorities for PCA and other ‘competitor’ policy instruments (such as carbon taxation) (Bottrill 2006a). A long list of research questions was generated. Included amongst the key research tasks were:

- Assessing the relative benefits of different policy instruments
- Investigating the public acceptability of different options
- Gathering better data on personal carbon profiles
- Researching the wider strategic policy fit of PCA – including an analysis of how it could affect pricing and energy supplier obligations
- Understanding the economic rationale for different options

Since this time, the Centre for Sustainable Energy (CSE) have produced for Defra a ‘road map’ for research into personal carbon trading (Roberts and Thumim 2006) and, based on this, Defra has developed a pre-feasibility work programme. The overall message is clear: far more research is required into all aspects of PCA. Without this, the policy cannot be properly assessed and many of the key questions about public acceptability, practicality and likely social and economic outcomes cannot be answered.

The UKERC route map identified trialling the PCA concept as a core component of a research programme. Support for the importance of a trial has also come from the Sustainable Development Commission who asked that ‘A full scale pilot and risk assessment on extending carbon emissions trading to individuals and small business be put in place before 2010’ as one of their Top 10 targets for government (Sustainable Development Commission 2005).

This report examines in detail the case for undertaking a trial study of PCA. Firstly the aims of the study are explained (Section 4), followed by a description of the methodology used to undertake the study (Section 5). The role of a trial is examined in Section 6, including its contribution to research knowledge, a comparison with other research methods and the challenges faced in implementing a trial. Section 7 looks in depth at operational issues and research decisions in a trial study. In Section 8 three possible PCA trial designs are outlined and costed. Finally in Section 9, conclusions are drawn and recommendations made.

Box 1: Trials and pilots

Throughout this report, we refer to a PCA ‘trial’ rather than a PCA ‘pilot’ scheme. This decision was made following early discussions with members of our advisory group and other consultees, which indicated that the word ‘pilot’ had attached to it a range of expectations and assumptions which the proposed study would not be able to meet. For this report, ‘trial’ means a real world experiment that as closely as possible replicates a real PCA scheme, on a small scale and for a limited time. In Section 6, the characteristics, benefits and limitations of potential trials are set out in detail.

4. Study aims

This scoping study has been funded by the Esmée Fairbairn Foundation and UKERC to assess the value and feasibility of running a PCA trial and to identify the associated financial costs.

The key questions for this study are:

1. What questions can be answered about PCA through a trial study? Would a trial therefore be worthwhile in research terms?
2. What would running a trial involve in terms of design, research methods and costs?

This report discusses the value and limitations of using a trial to build the evidence base about PCA; the range of questions that a trial scheme could investigate; the different research approaches that could be employed in the design of a trial; and an estimation of the cost depending on the different possible trial designs. It is sufficiently comprehensive to form the basis of a bid for funding of a trial scheme.

The scoping study team has in addition initiated dialogue with key stakeholders that are integral for lending support to a trial scheme such as central and local government, business and community organisations.

5. Study methodology

The study has involved workshops, interviews and literature reviews to canvass a wide range of academic, policy and community-based expert opinion about PCA trialling. An advisory group of eight people was established to guide the process. Two specialist workshops were convened to explore the benefits and limitations of running a PCA trial. In addition, twelve academics and other experts from a variety of disciplines and organisations were interviewed for their opinion of trialling. For full details of attendance at the workshops and individuals consulted refer to Appendix A.

The advisory group was made up of:

- Brenda Boardman, Environmental Change Institute, programme leader Lower Carbon Futures team
- Catherine Bottrill, Environmental Change Institute, researcher on PCA
- Tina Fawcett, Environmental Change Institute, researcher on PCA
- Julia Hailes, environmental consultant and author
- Chris Jacobs, Defra, civil servant responsible for pre-feasibility analysis of personal carbon trading (PCT)
- Geoff Lye, Sustainability, vice-chairman and associate fellow Environmental Change Institute
- Simon Roberts, Centre for Sustainable Energy, chief executive
- Richard Starkey, Manchester University and Tyndall Centre, researcher on DTQs

The first workshop was held in Oxford on 13 December 2006. Its purpose was to discuss what benefits and insights PCA trialling could provide and to compare them with what could be provided by other research tools. In addition, the workshop aimed to discuss what size sample and timescale would be required to draw meaningful conclusions from trialling.

The second workshop was held in London on 14 February 2007. This drew on a much wider audience than the first and was focused on investigating how

communities could be involved with a PCA trial. Discussions at this workshop considered how the scope and design of the trial(s) might interplay with the different communities that might implement trials. Three different types of communities were identified: geographically-based, workplace-based, network-based (e.g. membership organisations). Representatives of all three types of communities attended the workshop – with a total participation of eighteen people.

During the course of this study, the experts and academics listed in Appendix A were asked for their advice and opinions on running a PCA trial. Some of the expert input came early on in the process, when the study team was just beginning to outline how a trial might proceed, other input came later when our ideas were more fully developed. The aim of meeting the experts was to improve the quality of this scoping study by accessing a range of views from different disciplines, to ask for advice on relevant literature and to learn from others' experience. Although these experts and attendees at the two workshops are sometimes referred to as 'consultees' in this report, we did not carry out a formal consultation process, and have not reported separately on the views and contributions of each expert.

The final report has been through a two stage review process. In the first stage, five reviewers, three of whom were members of the advisory group, provided comments on the draft report. After these comments had been addressed, the final draft of the report went through a second stage review. Two independent academics, Dr Patrick Devine-Wright (Manchester University) and Dr Birgitta Gatersleben (Surrey University), reviewed the report in line with UKERC procedures. This process has been designed to ensure UKERC research reports are of 'publishable' standard (i.e. could be published in the international academic literature). In addition, Chris Jacobs (Defra) and an internal ECI reviewer also reviewed the final draft.

6. The role and conduct of the proposed trial

6.1 What is a pca trial?

The starting definition for a trial in this study was that: a trial would be a real world experiment that as closely as possible mimicked a real PCA scheme (Box 1).

The original vision was for the trial to be undertaken in a defined geographical area (say a city, county or island) and that within these boundaries inclusion in the trial would be mandatory for residents. Extensive IT systems would be in place, allowing individuals to track their own carbon emissions and trade carbon units, and there would also be a support network for all participants. However, attractive as this vision was in research terms, it very quickly became apparent that it would be extremely unlikely that a trial with mandatory participation would be acceptable (i.e. where participants could be held to their carbon allowances with penalties if exceeded). Many specific political, social and practical barriers were identified. Crucially, the advisory group and attendees at the first workshop felt that no local authority would be able to persuade or require its population to take part in a mandatory trial. The consensus view was that a more modest trial design was required.

All research trials are, by definition, limited in terms of participation and time compared with a full implementation of the policy being trialled. For PCA, there are in addition many aspects of the policy which are problematic to replicate on a small scale with voluntary participation. Full implementation of PCA would involve significant changes to everyday life, for example, introduction of a national personal carbon accounts system, much increased carbon awareness, information and incentives, a re-orientation of the UK economy towards low carbon options, and an understanding that personal allowances will decrease significantly

over time – with all that that implies for changing energy technologies, behaviours and lifestyles. PCA is a very ambitious policy proposal, and that makes it difficult to trial – but arguably increases the importance of attempting to do so. Nevertheless, if it is to go ahead a PCA trial must be able to deliver worthwhile research results, despite the inevitable differences between a trial and potential future introduction of PCA nationally.

The elements of PCA it should be possible to replicate in a trial include:

- allocating participants an annual personal carbon allowance, which reduces as they emit carbon from household energy use and personal transport;
- providing frequent feedback to participants on the carbon emissions from their energy use;
- explaining the cost implications of their carbon emission patterns (e.g. in terms of needing to buy additional carbon units if they emit more than their allowance) and possibly using ‘monopoly money’ (no real value) or ‘carbon tokens’ (a small real value);
- enabling virtual trading of allowances through the establishment of a hypothetical carbon market;
- educating participants about their responsibility for a share of the UK’s carbon emissions, and the necessity of rapid reductions in national and global emissions to avoid disastrous climate change.

The most important aspects of PCA that can not be replicated in a trial are as follows:

- real financial consequences for individuals based on their emissions. It will be difficult to expose voluntary participants in a trial to the true financial consequences of their carbon emissions (Section 7.1.5);
- full implementation of trading. Although some aspects of trading can be investigated

BOX 2: PCA in more detail

There is an ongoing debate about the detail of the best design for a national PCA scheme. This section does not try to resolve these debates, but presents one plausible PCA model as a basis for designing the trials.

The PCA model put forward is based on existing research and writing (Anderson and Starkey 2004; Hillman and Fawcett 2004; Fleming 2005; Starkey and Anderson 2005; Bottrill 2006a) and ongoing ECI and UKERC research. Appendix B details the wide range of options for the operational characteristics of a PCA scheme.

Key characteristics

- The allowance would cover all home energy use, private vehicle travel and air travel. However, public transport would not be included in the early years of the scheme (Bottrill, 2006b). Together these activities account for about half of UK national carbon emissions.
- The allowance would reduce annually in line with a national carbon reduction target.
- Each adult would get an equal and free annual allowance of carbon.
- Dependent children would receive a partial adult allowance, which would be allocated to adults as is done with the current child benefit payments system.
- Allowances can be bought, sold, saved and transferred to other people.
- The non-personal half of the carbon budget could be allocated to organisations and businesses through a scheme complementing PCA (e.g the Domestic Tradable Quota (DTQ) scheme proposed by Fleming (2005)).
- The annual allowance would probably be issued on a regular basis, for example quarterly or monthly to help with budgeting.
- People would have a carbon account from which to manage their carbon allowance. The carbon account would in many respects operate like a bank account.

Operational details and introduction of the policy

A national system of PCA would be introduced on a mandatory basis within, say, the next five years.

- As proposed in the Climate Change Bill, an independent carbon policy committee would establish a carbon budget in five-year increments capping the amount of carbon allowed to be emitted in the UK economy as a whole.
- Each five-year carbon budget would be adopted by Parliament fifteen years in advance.

When purchasing fuel, electricity or an airline ticket, individuals would have to surrender carbon units from their allowance as well as pay the financial cost. If the person had no carbon units, they would have to pay the additional cost of buying carbon units. People with no allowance, for example, tourists, would simply pay the carbon cost at the point of purchasing fossil-based fuel and travel services.

(Section 7.1.7), a trial will not be able to fully investigate the carbon trading aspects of PCA, particularly given that participants will not be losing or gaining real money within the trial (Section 7.1.5);

- a comprehensive carbon account and trading system. IT systems can be developed for the trial (Section 7.1.7) but they are unlikely to be as good as those in a national implementation of PCA given the likely limitations of funding for IT development within a trial;
- changes to the energy delivery infrastructure, regulations and support systems. For example, participants will not have to surrender carbon units at petrol stations when they fill up their cars, or hand over carbon units when buying plane tickets, energy bills will not include carbon information or advice, new businesses offering low carbon products and services (e.g. energy service companies – ESCOs) will not be present;
- the effect of living in a society oriented around long-term carbon reduction goals. Participants in a trial would know that they are only in it for one year (Section 7.1.1). A one year trial may not be long enough to accurately reflect the types of behaviour change people might adopt if the scheme was really being implemented. For example, in the course of a year-long trial participants are unlikely to spend money in changing to an efficient boiler or low emissions car. It is more likely they will engage in easy-to-do energy saving actions such as not leaving electronic appliances on standby or adjusting home heating controls;
- the social dimension of PCA. There will be no social pressure and no comparisons with other people (other than possibly participants in the trial). If PCA were introduced it would be introduced for all and this is likely to have significant social impacts.

Of the characteristics of a real PCA policy, a trial can best replicate the responsibility that would be placed on individuals to manage their own carbon emissions – by providing a goal (the average allowance), simulated incentives for reduction (via virtual trading and monopoly money), information about the importance of reducing personal, national and international carbon emissions and feedback on their own performance. It is less able to make the financial side of PCA (including trading) ‘real’ for participants. Without full inclusion of this aspect of PCA, there is a danger that the findings of the trial will in fact only indicate the attitudes and behaviours of people when involved in a process of carbon measurement and information feedback. This is a real challenge for a potential trial, and every effort would have to be made to make the financial side as real as possible within the known constraints.

Whether a trial with these characteristics can be expected to provide meaningful research results depends partly on how a PCA policy is thought to work. If PCA is viewed primarily as an economic instrument, which motivates people to reduce their emissions due to the financial costs / benefits of being over- / under-emitters, then a trial which does not involve real financial gains and losses is necessarily problematic. However, if PCA is viewed as a policy which operates by changing peoples’ relationship with their own carbon emissions, and engendering a greater interest in and ability to reduce emissions, and where the financial aspects of PCA are secondary, then the trial is more representative of the real policy. On reflection, some of the debates held during the course of this research may have arisen from different hypotheses about how PCA could influence individuals and society.

The authors' view is that PCA is much more than an economic instrument; it also has important moral and social aspects. It makes clear the responsibility each of us bears for reducing emissions from our consumption patterns, and sets this individual responsibility within a strong social context of a shared national goal. We believe the explicit transfer to individuals of knowledge about and responsibility for their own carbon emissions is a very powerful aspect of the concept. Existing research demonstrates the ability of people to save carbon and energy, given the right information and support, even in the absence of new financial incentives (Darby 2006; Global Action Plan undated). Given this view of PCA, the authors have been more convinced of the ability of a trial to produce meaningful data than some of those otherwise involved in the study. At this stage, however, it is not possible to know which view of PCA is correct (although that is something a trial could help elucidate). The following sections discuss the pros (Section 6.2) and cons (Section 6.3) of a trial in more detail, followed by conclusions (Section 6.4).

6.2 Potential benefits of a trial

The potential benefits of a trial can be grouped under three headings: research benefits, policy benefits, and a means of responding to and learning from ongoing community-led 'trials'.

6.2.1 Research benefits

A PCA trial would have several research functions. It would:

- investigate participants' opinions of PCA, based on their experience of living with the concept for a year. This aspect of a trial would provide valuable insights into the potential social acceptability of the policy;
- monitor the effectiveness of PCA in motivating attitudinal and behavioural change with respect to personal energy use, and investigate how these varied with economic and personal circumstances;
- seek to understand which aspect of PCA motivated any behavioural or attitudinal change, e.g. whether feedback, personal responsibility for carbon emissions or the simulated economic consequences were most important;
- test some of the detailed rules of PCA, e.g. allocation of partial allowances to children, both in terms of their effects, and participants' views of them;
- demonstrate, if positive outcomes emerge from the trial (e.g. reductions in carbon emissions), that PCA is a policy worthy of serious consideration. Conversely, the trial could show that at present this policy would not be likely to appeal to or motivate the UK public.

In order to provide these research outcomes, a PCA trial would need to collect many types of data, both quantitative and qualitative. These can be summarised under the following four headings:

- Quantitative data about participants and their carbon profiles
- Attitudinal data
- Behavioural data
- The capacity to respond to PCA (e.g. knowledge of energy saving options, opportunity and financial capability to invest in low carbon technologies)

Table 1 sets out a list of key research questions that could be addressed under each of these categories. This is an indicative rather than exhaustive list of questions. Much will depend on what research methods are used within the trial and what is asked of the participants.

Table 1 Research questions and issues addressed by a PCA trial

| Type of information | Research aims & questions |
|--|--|
| Quantitative data | <p>Collect carbon profile & socio-economic data of participating individuals and/or households.</p> <ul style="list-style-type: none"> • To analyse the range of household and individual emissions by household size, income, geographical location, family stage etc. • To analyse energy use and carbon emissions before and during trial. • Monitor carbon trading volumes and patterns. |
| Attitudes, understanding, social context | <p>To assess participants' experience of PCA and the trial</p> <ul style="list-style-type: none"> • How do people react to receiving an allowance? • What are the 'cognitive costs' (& benefits) in dealing with carbon? • What opinions of PCA do people have before and after the trial experience? How does this compare with their general environmental or governance attitudes? • Do any participants find the concept of a PCA difficult to understand? Who are they and why? • Does receiving a PCA change their understanding of energy consumption? • What do they think about the tradability of the allowance? • Do they think the allowance would change their energy behaviour? • What do they think about monetary value of carbon units? • Who joined the trial, who did not and why not? • Are there any peer-effects or inter-household effects influencing people's reaction to a PCA? • Do people feel the trial worked well? |
| Behaviour | <p>To assess behavioural responses to PCA</p> <ul style="list-style-type: none"> • How do people use the carbon account feedback and information systems? • Do the feedback and information systems influence participants' energy use? • What carbon and energy saving measures and behaviour changes do participants adopt during the trial? • What, if any, strategies do participants adopt for managing their carbon allowance? • Are there any peer-effects influencing participants' carbon and energy behaviour? |
| Capacity to act | <p>Assessing how people can respond to a lower carbon society</p> <ul style="list-style-type: none"> • What barriers do people find to reducing their carbon emissions? • What opportunities / support / information help people to reduce their emissions? • What additional and specific help would they value? • How do these vary by household size, family stage, income etc? |

Different types of data can be combined to get greater insight into key issues. For example, carbon emissions profile data before and during the trial can be combined with what people say they did to reduce carbon emissions. This will give insights into whether participants' actions were effective in saving carbon and if they accurately reported how their behaviour has changed. The attitudes of participants to PCA can be compared with their current carbon emissions and their capacity to act to reduce their emissions. Are these factors key to influencing views of PCA, or might this depend more on underlying attitudes to the role of government and individual versus collective action as suggested by earlier focus group research (Low 2005)? In addition, depending on how a trial is designed, there is also the opportunity to compare the PCA experience with some of the alternative policy approaches for reducing carbon emissions.

Many of the research outcomes from a PCA trial will have relevance to any low carbon policy which impacts on household energy use or personal transport. For example, the data on personal carbon profiles will be far more extensive and detailed than any currently available. The study will provide valuable insights into people's understanding of energy and carbon issues, what they think when presented with their own emissions and profile, and whether this understanding can motivate behaviour change. Identifying participants' capacity to act to reduce their own emissions will have important results for any citizen-focussed low carbon policy.

6.2.2 Trials as an important part of policy formation

In addition to its research contribution, a trial could be very important in terms of policy making. It might be that PCA could never be adopted as a policy in the absence of a (successful) research trial which demonstrated positive results and high degrees of acceptance by participants. Certainly,

trials or piloting has an important role in some areas of policy development, according to Sanderson:

"The scale of piloting and testing of new policy developments by the New Labour Government in the UK has indeed been significant in areas such as crime prevention, employment and welfare policy, health, education and local government." (2002:9)

Evaluations of pilot studies have been set up to answer two key questions: first 'does it work' and, second, 'how can we best make it work?' Sanderson quotes other researchers who have suggested that '..the use of pilots has been more akin to prototyping than to experimentation..' and that '..the piloting process is not so much about experimenting as about exemplifying..'. If exemplifying is an important part of policy adoption, then it is hard to see how PCA could be adopted in the absence of trial studies.

However, significant policy changes are not always preceded by trial studies. For example, taxation changes are not usually trialled, neither was the introduction of the Euro, decimalisation in the UK, or the London congestion charge (which generally succeeded) nor the Council Tax (which failed). Instead the effects of these policies were explored using a variety of methods, including modelling. When decimal currency was being introduced in Britain there were a number of imaginative studies conducted to find out how people would cope. For example, people were given mock decimal money and asked to do their shopping in a supermarket where all the prices were in the new currency. In each of these cases, though, there were powerful practical (and social / political) barriers which would have prevented a trial study taking place. The question of whether a policy can be adopted in the absence of a trial, where such a study would generate important knowledge and experience, is still an open one.

6.2.3 PCA experiments currently underway or planned

There is a significant amount of grass-roots activity around and enthusiasm for PCA or PCA-like trials. A recent report by CSE lists PCA-related and other low carbon initiatives (Redgrove and Roberts 2007). Current activities have not necessarily been designed with research outcomes in mind. Nevertheless their results could be extremely useful and could influence the policy agenda. Certainly it will be vital to make the best possible use of information emerging from these exercises in any future research PCA trial.

One of the most active groups is the carbon action rationing group (CRAG) network. A CRAG is a group of people who have decided to act together to reduce their individual and collective carbon footprints. They do this in annual cycle. First they set themselves an annual emissions target or "carbon ration". Then they keep track of their emissions over the year by keeping a record of their household energy use and private car and plane travel. Finally, at the end of the year, they take responsibility for any "carbon debt" (i.e. emissions over and above their ration) that they have built up. All carbon debts are paid into the group's "carbon fund" at an agreed rate per kilo of CO₂ debt. The fund is then distributed as agreed by the members of the group. Each individual CRAG decides its own rules on all of these issues – so they are undertaking negotiations about various 'fairness' issues related to PCA, which would no doubt be of research interest.

The network was founded by a number of enthusiasts at the beginning of 2006. The key founding members are Andy Ross and David Tonderai, both of whom are still strongly involved in the network. Andy Ross in particular has been responsible for inspiring a number of the current CRAGs to start up. In the summer of 2007, over 30

groups throughout the UK and beyond were listed on the network website (www.carbonrationing.org.uk). The CRAG network has received some positive media coverage (Greenall 2007; Slavin 2007; Taylor 2007) and is growing very quickly. Incidentally, two authors of this report are members of the Oxford CRAG.

In addition to the CRAGs, there are a number of organisations and communities who have expressed an interest in PCA trialling. For example, Sustrans is particularly interested in using the PCA concept to understand the travel-related carbon emissions of its staff. UKERC has been in touch with them and other organisations in the early stages of planning PCA or PCA-like schemes. Several organisations which attended the second workshop during this study were also enthusiastic about taking part in a PCA trial. Also a number of research and practitioner groups are seeking funding for implementing some form of PCA trial. As far as the authors are aware, these tend to be small-scale, qualitative type trials, which may be framed differently from the trials envisaged in this report, but which nonetheless have strong elements of PCA within them.

RSA are currently undertaking or planning a number of activities the results of which would inform a PCA trial. Work has begun in Cardiff to try and assess the carbon footprints (from home energy use and personal travel) of up to 2000 people, primarily via a questionnaire survey (RSA 2007). The outcomes of this work should be extremely valuable. Other planned work includes extending the use of their current virtual carbon trading platform 'CarbonDAQ', and possibly integrating it with an experimental carbon card to be used at petrol stations. This could test some aspects of PCA and participants' response to carbon allowances, feedback on their carbon impacts and trading opportunities. At present the methodology and

research questions are still under development. In addition, RSA are planning a ‘deliberative event’, which will be a one-day workshop investigating responses to PCA and carbon taxation with members of the public, to be carried out in early 2008 (Castle 2007). Both these latter activities could valuably inform a full research trial, but not replace it.

It would be beneficial to have co-ordination between existing community PCA trials to improve the robustness of trials and to capture learning and insights. Some initial ideas on this topic are presented in Appendix C. In addition, any future PCA research trial should include learning from voluntary carbon reduction initiatives.

Results from informal trialling, however interesting, are unlikely to be sufficiently convincing to make the case for PCA (assuming they show positive results). Given government and public interest in this policy approach, the research community needs to bring its skills and expertise to this area to undertake a well-designed research-led study.

6.3 Reasons for not carrying out a PCA trial

Within the PCA and energy research community there has been disagreement about whether carrying out a trial would be worthwhile. CSE published a report on individual carbon trading for Defra around the time this study began which suggested that PCA should not be piloted bearing in mind the poor state of current knowledge on PCA (Roberts and Thumim 2006). The type of pilot CSE had in mind was a mandatory scheme in a bounded geographical area – a model which was being discussed at the time. As acknowledged in Section 5.1, in the early stages of this study it was agreed that undertaking that type of pilot scheme was unrealistic, and that a more carefully thought-

out and modest ‘trial’ should instead be described and debated.

The main arguments CSE put forward for not running a pilot were:

1. The conditions which would apply in a real PCA scheme cannot be sufficiently replicated in a pilot, particularly the mandatory and national nature of the scheme;
2. The IT systems needed to run a pilot would not be sufficiently developed and participants’ poor experience of the systems could lead to failure and public distrust;
3. It is too soon in the research process to undertake a pilot while so much about PCA is still unknown;
4. Other research methods could provide valuable results.

The key questions which must be addressed for any proposed pilot scheme were identified as: “What would we be trying to achieve with a pilot or trial? Which questions will it answer?” As Simon Roberts pointed out in his foreword to this report, those questions are addressed by this report.

CSE’s first point has already been acknowledged in this report. As with any trial, there is the danger that results relate to particular conditions within the trial scheme. For a PCA trial, the most important weakness is probably the inability to replicate fully the economic consequences of PCA (as already identified and discussed in Section 6.1).

Interpretation of the results of PCA trials will be complex and require thoughtful analysis. Researchers running a PCA trial must be aware that behavioural and attitudinal changes which are observed may be due in part to particular elements of the trial, and not the PCA concept as a whole. Most importantly, the greater awareness of energy and carbon issues entailed by being involved

in a PCA trial will operate as a form of feedback to participants and has the potential to change their energy behaviour. A review of the effectiveness of feedback on household energy consumption was carried out recently (Darby 2006). The study looked at evidence from numerous feedback studies from around the world over the past thirty years. Energy savings from 'direct feedback' – that is from the meter or an associated display monitor – were usually in the range 5-15%. Darby concluded that the outcomes from feedback will vary according to circumstances. Feedback is necessary for energy saving but it is not always sufficient. So, while it is not possible to be certain that the form of feedback which is generated within a PCA trial will lead to household energy savings, based on the existing evidence, it is likely to do so.

Two other factors which researchers undertaking a trial should be aware of are: feedback effects on travel behaviour and the Hawthorne effect. There has been research showing energy savings from providing feedback to drivers via in-car meters and gear shift indicators, summarised in a recent report for the Department for Transport (Anable, Lane et al. 2006). Trial participants will be asked to record their travel behaviour and provide information on distances driven per month. As the level of feedback provided by this route is far less intensive than that provided in previous studies, no measurable effects on travel behaviour would be expected. Of more general concern for all trial studies is the 'Hawthorne effect': the possibility that the mere fact of being observed in a research project can influence the behaviour of those being observed. There are varying interpretations of the Hawthorne effect, which was discovered in relationship to worker productivity and changing working conditions. However, there is much critical literature indicating that, in general, the term 'Hawthorne effect' should be avoided in social research because it is not necessarily a valid concept (Wickstrom and Bendix 2000). There is no particular

concern that it would apply in this study, but it is something researchers should bear in mind.

In summary, great care must be taken to ensure potentially complicating factors are identified when interpreting results from any research trial.

CSE's concern about the adequacy of IT systems used within a trial is addressed in Section 6 of this report. Given experience of existing software, we believe it would be possible to design a workable information system for a trial study which would be adequate for the needs of the participants. However, as CSE noted, participants might have a negative reaction to the (inadequate) IT systems used in pilot, or indeed for other reasons unconnected with the core idea. This is important, and would be clearly of concern in any trial. The trial IT, communications and other practical aspects would need to be carefully pre-tested to reduce the risk of such misleading results arising.

More generally a trial will not be able to replicate the supportive policy environment expected if a PCA scheme were actually being introduced. A trial will be able to make efforts to create a supportive environment by giving instant feedback when participants provide home energy meter readings. But the wider social changes expected under a PCA system, involving business, government, energy suppliers, NGO, communities and individuals cannot be properly replicated in a trial, as acknowledged in Section 6.1.

Others consulted during this study have been concerned about different risks related to running a pilot. Experience from public and academic debates shows that PCA is an idea that evokes a wide spectrum of opinions from strong support to adamant opposition. A PCA trial could have effects well beyond the generation of knowledge. A trial, and the potential publicity and high profile surrounding

it, could result in PCA being submitted to detailed and hostile scrutiny before sufficient evidence and argument was available to defend the concept and its implementation. If trials demonstrate positive reasons for introducing PCA, this message might not be heard against negative background opinion. This same reaction might be less likely to be triggered by lower-profile research methods such as focus groups, opinion surveys or modelling. It is difficult to know how real this risk is. But it seems inappropriate to base a research strategy on fears of a negative reaction. It would be much better to reduce the risk of hostile reactions to a trial by having a clear communication strategy and being prepared to answer criticisms. PCA researchers with experience of presenting to a wide audience understand many of the doubts and objections that the idea provokes, and already have answers to many concerns that typically arise.

CSE questioned whether it was too soon in the PCA research process to run a trial. A PCA trial is a complex piece of research, some aspects of which would be simpler if results from a large-scale carbon emissions survey or focus groups were already available. While it is possible to argue that a trial should be delayed for a year or two, this only makes sense if a strong, well-funded PCA research framework is in place. In the absence of such a framework, and given the urgent need to develop new, effective policies for carbon reduction, a PCA trial should be undertaken as soon as possible if funds can be secured.

During the course of this study, many people have suggested alternative research routes which could provide some of the data and insights sought from a trial. The main options are:

- Focus groups
- Trading simulation games
- Large-scale carbon profile survey

Focus groups, if well designed, can be an effective method of exploring people's attitudes to the concept of PCA and alternative carbon reduction policies in more depth than, say, a questionnaire. In Section 2, the very interesting results from Low's (2005) focus groups were highlighted. However, focus groups cannot be used to explore many of the questions a trial would address. While capable of giving a snapshot of people's initial and subsequent attitudes to PCA, they cannot give any hard evidence on behaviour or attitude changes as a result of living with an approximation of PCA for an extended period. Neither can they provide detailed evidence about how reactions to PCA policy vary with individual carbon emissions and opportunities for change. Focus groups could be used in various ways to pre- and post-test aspects of a PCA trial (with both full and lapsed participants), and in general are probably most useful in conjunction with other sorts of research evidence.

In their report to Defra, Roberts and Thumim (2006:36) specifically recommend developing and testing simulation games and trading systems games for groups as an alternative to 'pilot' schemes. They suggest these could explore whether people bother to trade and what gaming takes place within a trading system. However, simulation games potentially suffer from the same criticism as a trial study: they cannot replicate a real PCA scheme. The level of 'reality' a simulation game provides depends on how the simulation is undertaken. More detailed simulations might share many of the characteristics of a trial. However, basic simulations or trading games are likely to provide much more limited results than a trial.

A large-scale carbon profile survey of several thousand people covering household energy use, personal transport and aviation, would provide extremely valuable data which would be useful for many different research purposes. It would enable analysis of the range of personal carbon emissions in

the UK, how they vary with socio-economic factors, how many ‘winners’ and ‘losers’ there could be initially under PCA or carbon taxation policies and so on. It would be extremely useful to a PCA trial if data from such a survey were available before the trial began. However, while providing very useful quantitative data, questionnaire surveys are necessarily limited in the insight they can give into many of the behavioural, attitudinal and social acceptability questions about PCA. A number of attitudinal questions could be attached to a survey, and if well designed might provide useful results. Nevertheless, it is problematic expecting people to give considered responses in a survey to a policy idea they have probably never heard of before. Thus a survey would broadly complement rather than replace a PCA trial.

It is beyond the scope of this report to explore fully the many research activities needed to undertake a thorough investigation into PCA. This report seeks to investigate the case for a trial, but does not attempt to design a complete PCA research programme including the many possible activities and methodological approaches. As mentioned in Section 2, a number of documents identifying the research needs for PCA already exist. All of the types

of research above could provide valuable data and insights into different aspects of PCA. However, none of them is capable alone, or in combination, of offering the depth or breadth of insights which a well-designed trial could provide. Nor could they answer most of the research questions identified in Table 1.

6.4 Conclusion

The pros and cons of carrying out a PCA trial are summarised in Table 2. As with all behavioural research, PCA trialling cannot demonstrate exactly what the effect of PCA would be in practice, or how people would react if it were introduced nationally. There would be too many differences between the trial and real introduction of PCA to make this possible. In spite of this, the significant value which could be drawn from a research programme in relation to a potentially critical lever in shifting society towards low carbon lifestyles warrants the level of investment required.

The following section discusses in detail how a trial could be carried out.

Table 2: Summary of PCA trial pros and cons

| Pros | Cons |
|--|--|
| Provides research evidence about PCA unavailable from other methods of enquiry, particularly with regard to social acceptability. | Doubts about the validity of using data from a trial to draw conclusions about a national PCA scheme. |
| Uses a variety of methods and sophisticated analysis to gain a deeper understanding of PCA, and people and their carbon emissions. | Other lower-risk and less problematic research methods could provide some (or much?) of the data generated by a trial. |
| If the trial is successful, provides exemplification of PCA in action. | A PCA trial may be valuable – but other research should be carried out first |
| Responds to and improves on existing community initiatives. | |

7. Trial design options

This section of the report discusses key issues around PCA trial design and the research methodologies which could be employed. Sections 7.5 and 8 use the results of these discussions to specify in more detail how we propose PCA trials could work. Firstly, the likely demands on participants in a PCA trial are explained. These form the backdrop to the subsequent discussions around sampling, methods of data collection, and recruitment and retention of participants.

7.1 Participants' experience of a PCA trial

The aim of the PCA trial is to closely replicate as many key elements of real-life PCA as possible, while not placing an unreasonable burden on participants. The trial design must balance the conflicting aims of collecting as much research data as possible while providing an experiment which people will sign up for and stay engaged with over time.

7.1.1 Length of the trial

We propose that participants should be involved in a PCA trial for one year. The key reasons for proposing this period are:

1. Household energy use varies greatly with season. Participants need to understand the interaction of their carbon allowance with winter and summer energy use patterns to have a full appreciation of how a PCA scheme would affect them.
2. International travel varies throughout the year, with more travel in summer. Again it is important to capture this annual variation and its interaction with PCA.
3. A year gives participants time to get used to PCA, understand the scheme, react to it and reflect on it.
4. Our hypothesis is that participants' understanding of and opinions of PCA will vary over time and with their experience of it. The trial period should be long enough to test whether this is the case.
5. A trial running for more than a year would increase costs and likely drop-out rates, and would not necessarily add greatly to the knowledge gained in the first year.
6. It would be difficult to allocate a 'fair' PCA for part of a year, given the seasonal variations of carbon emissions (which although understood in outline are not well characterised).

However, two of the academics we have consulted have suggested that it could be possible to run the trial on a rolling, three-monthly basis. In this way, there would be less of a burden on participants, as they would only be asked to participate for three months, and it would be possible to have the trial operating at each different time of the year. The key advantages of this method would be that it should be easier to recruit and retain participants, and could prove a lower cost experimental design (depending whether more participants were recruited than in a year-long trial). But, it does not offer any research advantages, and we believe it would provide less useful information than a year long trial, given points 1 – 5 above.

There is also an argument that to get complete 'before and after' energy data, participants energy consumption and travel patterns should be monitored for a year before the PCA trial begins. In order to avoid this additional time (and cost) commitment, there may need to be a selection criterion for participants based on being able to access energy and travel data for the previous year.

Given that each participant will be involved in the trial for one year, there is no particular reason why all participants would have to be recruited to begin the trial in, say, January, and finish in December. For practical reasons, it may be more convenient to run a process of rolling recruitment where a set of participants begins the trial each month over a period of several months.

7.1.2 Frequency of data collection

Participants will be asked to provide data of various sorts, via various methods (discussed in more detail in Section 7.3) throughout the trial. Involvement in a PCA trial will require active engagement by participants. They will need to report energy use data regularly and receive related PCA feedback as well as to complete questionnaires and be interviewed about their experiences. Again there is a balance to be struck between what researchers would like to learn, and what seems reasonable to ask of participants.

At the start of the trial, participants will be asked for three types of information:

- Demographic and general environmental attitudinal data. This will allow the sample to be characterised and compared with the general UK population.
- Their views on PCA or other low carbon policies. This forms the baseline attitudinal data for the rest of the trial, by collecting participants' initial thoughts and opinions on PCA. Questions about their motivation for joining the trial could also be included.
- Energy and travel data to allow their previous year's carbon emissions to be estimated. This would consist of energy bills (or permission to contact their energy supplier), records of car mileage driven, details of car model and memory of flights

taken. Using this data, a 'before' account of carbon emissions can be calculated, and given to the participant as a useful form of feedback. It will also allow numerical analysis of the effects of behaviour changes during the trial.

During the trial, participants will be asked to provide regular updates on their household energy use and travel by car and plane. These will be used to calculate participants' carbon emissions to date. There are two reasons for this. Firstly, it provides research results on patterns of carbon emissions throughout the year. Secondly, it is the only way in which to provide participants with information on how their emissions compare with their remaining carbon allowance. In a real PCA scheme the process of reporting energy use and surrendering carbon units would be automatic when people put fuel into their vehicles, paid their home energy bills or bought a flight – in the same way as credit is deducted from telephone and Oyster travel cards. However, in a trial researchers must capture this information and feed it back to participants.

We propose that participants are asked to provide energy and travel data on a monthly basis. It seems unreasonable to require more frequent provision of data (although more frequent data entry and feedback would be possible if an internet data tool were used). The reasons for asking for monthly, rather than less frequent reporting, are:

- It reminds people they are involved in a PCA trial, which is likely to be beneficial in increasing the 'reality' of the trial.
- If a participant stays through the year long trial there should be 12 data points for a researcher to analyse and if they drop out along the way, a partial data set will be available.

The provision of regular energy use data could be pre-tested before trialling begins to ensure this method is acceptable to participant and delivers the necessary data to researchers, and to discover what support participants need to help them read their energy meters accurately.

In return, participants would be promptly provided with feedback on their energy usage in terms of carbon emissions for the previous month by activity (household energy / travel – with air travel reported separately) and a comparison with their carbon budget for the year. The format in which this feedback would be provided will depend on the data collection methodology – e.g. it could be done by email in an internet-based trial. The existing feedback literature (e.g. Darby 2006) will be used to understand how feedback should be best delivered to participants.

Ideally the initial PCA and attitudes research should be repeated during the trial period, along with gathering participants' reflections on the process of being involved with the trial.

At the end of the trial, participants would again be asked about their attitudes to PCA and other low carbon schemes, and questioned in detail on their views of the trial – what aspects were good or bad, whether it was difficult to understand, whether and how their behaviour changed during the trial, whether they intended to continue with a lower carbon lifestyle and so on. The aim would be to get a rich understanding of how participants view PCA and (separately) the trial process and how they responded to it.

The final set of data on energy use and travel would be used to calculate annual carbon emissions for each participant. These can be analysed in themselves and compared with the previous year's emissions estimated at the start of the trial.

Anticipated interactions between researchers and participants are summarised below (Table 3).

Table 3: Interaction with participants during the trial

| When during trial | Interaction |
|----------------------|--|
| Start of trial | <ul style="list-style-type: none"> • Estimate previous year's carbon emissions –based on utility bills, car MOT and memory of air flights. • Demographic questionnaire. • Attitude questionnaire / interview focused around PCA. |
| Monthly during trial | <ul style="list-style-type: none"> • Participants read energy meters and car milometer and report international travel to researchers. • Researchers provide feedback provided on carbon emissions, carbon allowance remaining, and £ value of carbon units used and unused. |
| Throughout trial | <ul style="list-style-type: none"> • Possible ability to 'trade' carbon (see section 7.1.7) • Occasional attitude questionnaire / interviews |
| End of trial | <ul style="list-style-type: none"> • Attitude questionnaire / interview focussed around PCA. • Energy behaviour questionnaire / interview. |

7.1.3 The boundaries of the carbon allowance

As explained earlier, a personal carbon allowance would include carbon emissions from household energy use and personal transport and carbon equivalent emissions from air travel. However, although in principle PCA would include emissions from public transport (i.e. bus, coach, train, other rail options, taxi), there are practical reasons for excluding public transport from the scheme, at least in the early years of introduction. The key arguments for not including public transport initially are:

- public transport comprises only a small percentage of individuals' travel emissions (Brand 2006);
- inclusion of public transport could easily double or treble the total number of carbon credit transactions per year, while only affecting a small proportion of personal emissions;
- it reduces the need for costly infrastructure on public transport;
- it is difficult to calculate the emissions associated with an individual's travel on different public transport modes due to fuel choices, occupancy and distance travelled (Bottrill 2006b).

By not including public transport, there would be additional motivation for individuals to switch away from private to public transport and more onus on transport operators to reduce their fleet emissions (as the organisations would be responsible for all their operational emissions and carbon trading).

We propose that this logic would also be reflected in the trials. Participants would not be asked to record their journeys by public transport; only travel by car would be counted for the 'personal travel' activity. In order to

make this as easy as possible, participants will be asked to record mileage in the car(s) they drive monthly (rather than using, say, records of fuel purchased) and provide details of the car model (so researchers could do calculations based on its carbon emissions per kilometre). This would greatly reduce the data collection burden for participants in the trial, and, as noted above, excluding public transport will only have a small effect on understanding total personal carbon emissions. Researchers would have to set out clear guidance for participants on distinguishing between personal and business travel, as only personal travel would be counted in the trial.

7.1.4 Setting and issuing the annual allowance

The level at which the carbon allowance is set for the trial will influence participants' experience. In order to replicate a real PCA scheme, the allowance level could be simply set at the current national average emissions or up to 1–3% lower (as might occur in the first year of a real implementation of PCA). However, given that approximate carbon profiles of participants could be known by the time the trial period begins, it would be possible to adapt the allowance based on the average emissions and distribution of emissions within the group. So, for example, the allowance could be set such that half the participants were above allocation in the preceding year and half were below. If the average emissions of participants were very different from the national average, particularly if they were much lower, setting a trial-specific allowance might make more sense than using an average figure. This approach would not work if a system of rolling recruitment (described briefly in Section 7.1.1) were employed. Because giving participants an allowance based on the national average best replicates a real PCA scheme, it is the preferred approach for a trial.

As in a real PCA scheme, all adults should receive the same allowance, whatever its level. To the extent that children are included in the trial, they should receive one third to one half an adult allowance until the age of 16 or 18. In the absence of sufficient research on the carbon impact of children on households, one third to one half an adult allowance is a simple guess of what children 'need'. UKERC is planning further research on the carbon emissions of children, and possible allocations of emissions under PCA.

There has been some thinking about how often carbon units should be allocated in a real PCA or DTQ scheme (Fleming 2005; Starkey and Anderson 2005). However, in a trial the total number of carbon units for the year would be given to participants at the start of the trial. This is the simplest form of allocation, and seems most likely to be comprehensible to participants. Allocating an allowance monthly, say, could create a lot of confusion given the seasonally varying nature of carbon emissions. While this might be resolved within a real PCA scheme by use of rolling allowance allocations, so people always had enough allowance to cover their emissions for the next several months, in a trial simplicity seems the best option. However, this aspect of trial design should be discussed with participants in pre-trial testing.

7.1.5 Incentives and penalties

In a real-life PCA scheme, some people will have spare allowances to sell and will gain financially by doing so, whereas others will have to buy additional carbon to enable them to continue with their accustomed energy use patterns, and this will cost them additional money. There will be winners and losers. The financial incentive that PCA will provide for behaviour change towards lower carbon living is an important component of the policy. However, in a

voluntary trial it is our judgement that we will not be able to recruit people if they risk losing their own money by being involved.

Given this, will it be possible to replicate the cost implications of PCA in a trial in any way? The options are:

1. Do not use any real financial incentives in the trial. 'Monopoly money' could be used instead
2. Offer rewards to those coming in under their carbon budget, but do not actually penalise those who are over.
3. Use real financial incentives in the trial, equally for under- and over-emitters, but with money supplied by researchers, so that nobody loses financially by being involved in the trial.

Option 2 would build in asymmetric economic incentives, and advice from economists is that it would skew responses in the trial. This leaves a choice between options 1 and 3. Under Option 3 each participant could potentially 'earn' the same amount of money from the trial, but in reality each would end up with a different payment, depending whether they were under- or over-emitters. Payment could only be made at the end of the trial period. This type of payment structure would give participants a financial incentive to under-report their carbon emissions. There is some evidence from experimental economics that individuals' behaviour in trials can differ depending whether incentives are real or hypothetical (monopoly money) (Elderkin 2007). Given the constraints of research budgets, and the complexity of dealing with real money, Option 1 is probably the best choice for PCA trials. However, this issue should be revisited with the help of relevant economic experts if a trial is commissioned.

Choosing Option 1 will mean that an important aspect of PCA will not be fully replicated within the trial, and the best that can be done is to use information or ‘Monopoly money’ to communicate to participants the financial consequences of their carbon emissions. How the incentives and penalties are communicated to participants will depend partly on whether a trading element is included in the trial (discussed in the following sections). The aim would be to enable the participants to understand what the financial consequences of their emissions (whether above or below allowance) would have been – and to gauge their reaction to this.

7.1.6 The price of carbon

In order to communicate to participants what the financial impact of their carbon emissions would be, a price of carbon will need to be set for the trial. In a real PCA scheme, the price of carbon would reflect the balance of demand for additional carbon units compared with the available ‘spare’ carbon units in that allocation period. The price of carbon and thus the availability of carbon units would be linked to a national carbon market, possibly even an international carbon market, which is reflective of the carbon cap. It is open to debate whether the price of carbon paid by the householder would be identical to that paid by business (at present set under the EU Emissions Trading Scheme (EUETS) for obligated businesses). There are arguments for protecting individuals from the large price fluctuations that have been experienced within EUETS, but also counter-arguments that it would not be sensible to have differing carbon prices for individuals and organisations.

In order to set the carbon price, the latest information from the existing EUETS carbon market could be used, in addition to projections

about what the carbon price would be under tighter carbon caps. There is also research available on the ‘social cost of carbon’ – which is another approach to pricing (Clarkson and Deyes 2002). However, there is no guarantee that either of these approaches would reflect the price that would emerge in an actual PCA scheme. For a trial, expert judgement would be required to estimate a price likely to exist in the first year of a PCA scheme.

7.1.7 Including a carbon trading component in a PCA trial

In real-life, trading would be an inherent part of PCA. Over-emitters would have to buy additional allowances either directly or through higher prices on their energy purchases and under-emitters could make money by selling what they don’t need. However, in a trial which does not require that participants face real financial penalties, the role of trading is problematic both in principle and in practice. There are questions about how meaningful ‘virtual’ trading would be, what research questions it could be used to answer and how it could be incorporated in a trial in practice. Nevertheless if a virtual trading element can be included in the trial, participants would get a fuller picture of PCA and researchers could learn more about how the trading component of the policy could work. A number of contributors to this study (via workshops and individual interviews) have stressed their view that it is vital that some form of trading be included in the trial so that the trial really is about PCA.

A trading element could be added to the trial at a variety of levels of sophistication. At the very simplest level, at the end of the trial both over- and under-emitters could be asked what they would have done should real money have been involved. Would they have altered their

behaviour more? When would they have bought and sold allowances? Would under-emitters sell or save their annual surplus? The most sophisticated implementation would probably involve a dynamic, web-based personal carbon account, which is an extension of the carbon measurement platform participants are already using to enter monthly meter and odometer reading data. Participants will have the flexibility to buy and sell carbon units through their personal carbon account. There would be a mock carbon market which set the price for carbon and a suitable data collection system which could be used to analyse patterns of trading. Neither of these implementations of trading would replicate the real thing, and so in either case data would have to be interpreted with care.

In order to incorporate virtual carbon trading in the trial, there are a number of questions which need to be answered:

- Should the price for carbon fluctuate? If so, on what basis?
- What aspects of participants' trading would be of interest and how would this data be captured?
- How can the trading be designed so as not to encourage more 'gaming' than might occur in a real PCA scheme?
- When would participants be encouraged to trade – e.g. at any time, each month, only at the end of the period?

Including virtual carbon trading as an integral element of a PCA trial is challenging and will require additional research time and software development. However, because of its importance within PCA we propose that internet-based trading should be included trials which already intend to make use of internet data collection and feedback tools. In Section 8,

three possible trials are outlined. One includes no trading, one offers trading possibilities to some participants, the third includes trading for all those participants testing PCA.

7.1.8 Accuracy of energy and travel data

All participation in the trial is voluntary and participants will be trusted to accurately report their energy use to the best of their ability (with error-checking software being used to query any unusual readings). It might be possible to validate the reliability of participants' energy use reporting by asking a random sample to submit copies of their energy bills (or permission to contact their energy supplier), MOT certificates and flight receipts. If there is a plan to do this then participants would need to be aware from the outset they might be asked for this information and given an explanation of why they might be asked (e.g. to validate result analysis) so they understand the research process and to minimise feelings of intrusion.

7.2 Sample selection

Identifying what sampling strategy to use for a PCA trial is probably the most fundamental decision to be taken. It will determine how representative the trial population is of the general population, whether groups of special interest are included (e.g. low income or elderly people) and, most importantly, how the results of the trial can be interpreted. Sample selection strategy will also strongly influence the cost of any trials.

7.2.1 Can a representative sample be selected?

Recruiting a representative, random sample of the population of interest (where every member of the population has an equal chance of being chosen) is often a research ideal. However, it is

unlikely to be achievable with PCA trials. This is because the trial makes rather onerous demands on participants. They will be asked to take part in a study continuously for one year, where they are asked to interact with researchers on a monthly basis (as explained earlier). Given the demanding nature of the trial, it is highly unlikely that a random sample can be recruited, and, more importantly, retained, for the length of the study. By way of comparison, an expert consulted during this study told us that surveys which attempt to contact randomly-selected people on the doorstep to answer a one-off questionnaire, struggle to achieve a greater than 70% response rate, even with repeated visits. Thus in a PCA trial, there will inevitably be a degree of 'self-selection' by participants. This then limits the extent to which any PCA trial can be representative of the UK population.

Accepting that participants in a PCA trial will be self-selecting, what can be done to ensure that the sample is as representative as possible of the general population? And what characteristics of the population are the key ones to mirror in the sample? Ideally, trials would recruit participants with a distribution of personal carbon emissions similar to the whole UK population and with a similar 'capacity to respond' to PCA. These factors will determine how PCA will affect an individual in the first years of PCA policy being introduced. Capacity to respond is a concept which includes a wide range of factors including a person's opportunities to improve the efficiency of their home, car and appliances, access to renewable and low carbon energy sources, travel patterns, public transport alternatives to the car and financial capacity. Willingness to cut down on flying or alter other carbon-intensive aspects of their lifestyle is another factor in an individual's capacity to respond, but one that cannot be determined

so clearly in advance of the trial. It is likely that participants will show more willingness to cut their carbon use than non-participants.

Unfortunately there is little or no information on how either factor varies within the UK population. Information on personal carbon emissions is only known for small samples of people (Fawcett 2005) or has been estimated for different income groups using proxy expenditure data, (Ekins and Dresner 2004). It is necessary to know how large the variability (of carbon emissions) is and what the variability associated with, e.g. regional variation, socio-economic factors, in order to determine the size of sample needed to be representative of the population. However, as this is unknown, according to the statisticians we have consulted, regardless of other complicating factors, it will not be possible to design a trial which selects a sample which is representative of carbon emissions variation across the country. There is no information or research on the concept of capacity to respond – and it seems very unlikely any account can be taken of this important factor in a sampling strategy.

Despite these limitations, caused by both needing a year-long trial and by lack of data, there are methods which can improve the information gained from the samples chosen. Firstly, the degree of self-selection in terms of environmental behaviours and attitudes, income, carbon emissions and so on can be compared with existing data about the UK population as a whole. In this way, the differences between the trial and UK populations will be well understood. This will be vital for sound interpretation of the results of the trial. Secondly, in order to improve sampling by having a better understanding of the distribution of carbon emissions profiles in the population, one could get a first impression

of variability from a pre-trial study whose results could inform the design of the actual trial. By estimating personal carbon emissions, together with collecting demographic details, more information would be available about how to structure a sample so as to get a full range of carbon emitters in the trial. Alternatively, given the expanding research interest in personal carbon emissions, it may be that more data on the variability of carbon emissions is available by the time a PCA trial begins.

7.2.2 Geographical distribution of the sample

There are a number of practical advantages to choosing participants clustered in one or a small number of locations rather than recruiting them irrespective of geography. These are:

- Reducing the costs of face-to-face interviews, questionnaires and focus groups by reducing travel time for researchers;
- Allowing personal support to be delivered to vulnerable participants in a cost-effective manner (e.g. help with energy meter reading);
- Making use of existing community networks for recruitment and support;
- Ensuring participants will be operating in the same local context in terms of opportunities for lower energy and carbon choices. For example, participants will have the same access to information and programmes run by local authorities and voluntary groups.

Given these advantages, the three trials outlined in Section 8 are all based on geographically clustered samples.

7.2.3 Choosing a specialised sample

As discussed earlier, we know a PCA trial will not be able to attract a sample representative of the UK population. Efforts could be made to ensure

the sample is as representative as possible, but one of the experts consulted during our research suggested employing a totally different strategy. He proposed that a trial could be designed using a targeted sample of 'future featurers'. Future featurers or 'lead users' are used in market research and are described as 'consumers with a passionate interest in a given product who single themselves out and may be used to explore future developments of the product'. Future featuring makes use of three key philosophies and related methodologies. The first of these is the belief that 'the future exists in the present'. The future may be found by talking to consumers with an active or passionate interest in a particular field. Secondly, these people may be identified and recruited through an open invitation to a large audience. Thirdly, in the project itself lead users set their own agenda based on their own views and experiences as consumers in the real world (Aldersey-Williams, Bound et al. 1999).

For this trial, this would mean recruiting participants who are already carbon-aware and concerned to do something to reduce their personal carbon emissions. The main justification for doing so is the argument that if PCA were to be adopted as a policy, this could only happen if the population were more like this carbon-aware group and therefore likely to support a government-led initiative or policy. If this sort of group were recruited, then interpretation of data from the trial would have to be quite different than if a 'normal' group were recruited.

There is considerable concern about the potential effect of PCA on various 'vulnerable' social groups, including the poor, the elderly, the less well-educated and people with disabilities. Therefore there would be good reasons for recruiting a specialised sample from one or all

of these groups. This could entail additional challenges for researchers. For example, some groups may require additional support with completing questionnaires, reading their energy meters, interpreting feedback on their energy use and carbon emissions and so on. Finding out the extent of additional support needed by vulnerable groups to enable them to fully take part in a trial, and devising means to provide that support, would be an important task in any pre-trial testing.

In terms of cost, recruiting a highly motivated group of 'future featurers' should make little difference to running the research project, with the possible exception of drop-out rates. It seems plausible that future featurers would be more likely to complete the whole trial period than participants from the general population. Members of local CRAG groups would provide a possible specialised sample. So choosing a carbon-aware sample might reduce the numbers who have to be recruited initially to ensure the target sample number is retained till the end of the trial. The results of the trial would be biased and there would be significant limitations about what is possible to infer about the range of reactions to PCA if introduced nationally. However, this type of trial would provide a reasonable indication of how the population might react to the idea of introducing a PCA if they were more carbon literate.

On the other hand, recruiting vulnerable participants would probably entail additional support costs and could result in higher drop-out rates. Working with these groups is also likely to favour particular research methodologies and means of communication, which are discussed in further detail in Section 7.3.

7.2.4 Sample size

The size of sample chosen clearly has a very important influence on the evidence-base provided by a trial. Larger sample sizes are nearly always preferred as they naturally include a wider (and hopefully more representative) group of participants. However, in terms of practicalities, larger participant numbers significantly increase project costs. Also, a larger sample size can impact on the trial timescale. Some researchers and practitioners consulted during this study with experience of recruiting participants for trials have warned that trying to recruit, say, one thousand people would be extremely time-consuming and expensive.

There can be a trade-off between doing more in-depth qualitative research with a smaller sample, compared with less comprehensive research with a larger sample. Depending on the research design and aims, it is possible that understanding the attitudes, values, behaviours and experiences of 100 people in depth, would provide more insight into PCA than a study of 1000 people which relies entirely on questionnaire responses. For a small sample (or sub-sample), it is more realistic to undertake interviews or focus group research which can explore experiences, thoughts and feelings in greater subtlety and detail.

There is no definitive 'right' sample size for a PCA trial. The trial options outlined in Section 8 take varying approaches to sample sizes.

7.2.5 Recruiting households or individuals?

In a real PCA scheme, all adult members of a household would be involved in carbon budgeting and would have their own individual allowance. However, in a trial it could be

possible to have different levels of household participation from just one adult member of the household to all members of the household. The different options are:

- Option 1: One person per household recruited, reports only his or her own energy use only;
- Option 2: One person per household recruited, reports total household energy use and all mileage for shared as well as individually-driven cars but personal air travel only;
- Option 3: All adults per household recruited, report total household energy use and all individual and shared travel, each given a PCA, but can choose to set up a household carbon account;
- Option 4: All people in the household, including children, recruited and involved in some way. A household level PCA is given.

Options 1 and 2 are very similar: the aim of both options is to gather full data about one member of the household only. The difference is that Option 2 could make reporting energy use and car mileage more straightforward for participants because they report data as they collect it: actual household energy meter and car odometer readings. Rules for dividing domestic energy use between householders (taking into account the total number of both adults and children) and dividing mileage for shared cars will have to be devised and communicated to participants in either option, but in Option 2 the researchers do the sums to allocate a share collective of energy use to one individual. We propose that Option 2 would be more suitable than Option 1 for the research trials. However, this is something which could be pre-tested before the trial begins to check that people understand how collective energy use and shared travel interacts with the concept of personal allowances. Option 2 also allows

the possibility of giving some feedback at the household as well as the individual level.

Both Options 3 and 4 require some involvement from more than one person in the household. Option 3 suggests each adult in the household should have equal involvement in the trial, whereas Option 4 could involve one key respondent participating on behalf of all household members. In Option 3 it won't be possible to communicate clearly the effects of having children on the carbon account and budget. These options would have the added advantage of opening up additional research questions about intra-household dynamics. They also reflect the fact that under a real PCA scheme, everyone in the household would have some form of allowance. The difficulties identified for Options 1 and 2 of fairly apportioning shared household emissions to participating individuals would be largely avoided.

Several of the experts who were involved in discussion about the trials suggested there could be a number of benefits to involving children in the trial as participants. These included the motivation and enthusiasm children would bring to the project and the proven record of children in helping monitor and save energy within their families. At a minimum, Option 4 would involve specifically allocating children an allowance as part of the household PCA budget.

The main concern about Options 3 and 4 is that by increasing the amount of data collected (by involving more household members) recruitment will be made much more difficult. Recruiting all adults in a household into a study, particularly for non-family households, could be problematic. This additional difficulty may be less important than the extra data and insights

gained from involving multiple household members. Of the two options, Option 4 would probably be preferable as only one respondent per household is required, although that person would still have to gather and present personal travel data on behalf of all household members. There is a risk that, compared with Option 1 or 2, this could increase response errors and result in less reliable data.

Opinion was divided amongst those consulted for the study on whether an individual or household data gathering strategy would be preferable. For the remainder of this report, it is assumed that Option 2 is chosen rather than Option 4. However, the authors recognise that this is a finely balanced decision, and that if a trial were to go ahead it might well opt for a whole-household recruitment approach.

7.3 Methods of data collection

There are a variety of possible methods for collecting data and interacting with participants: individual face-to-face interviews, discussions within focus groups, via telephone interviews, through paper-based questionnaires and by internet-based questionnaires and contact. Each of these methods will have different costs, research advantages and disadvantages and may affect the information which can be collected from and feedback given to participants. The method(s) chosen could also affect the experience participants have of the trial. Our aim is to identify cost-effective, robust methods of data collection and interaction which are well-designed and do not dominate participants' experience of PCA.

7.3.1 Questionnaires

Some of the types of data to be collected from participants are most effectively gathered via questionnaires which ask closed questions. This would include all the demographic information about participants, and at least some of the attitudinal data. Using questionnaires would provide this type of information in a cost-effective and easy to analyse format. In a trial, questionnaire administration and results collation is likely to be undertaken by a market research company, as this is standard research practice.

Questionnaires can be administered by telephone, in person, by post / email or via the internet. These methods of collection vary in cost and other characteristics, but all have a track record of providing good quality results in the right circumstances. The market research company we spoke to during this study provided some guidance. They suggest that for long questionnaires, face-to-face delivery is most suitable. Most telephone interviews last no longer than 20 minutes, whereas when interviewing in the home it is possible to continue for up to 45 minutes and retain the attention of the participant. Questionnaires administered across the internet should take no longer 15-20 minutes otherwise participants are likely to lose interest and fail to complete the survey. Method of delivery of questionnaires would be decided in collaboration with the market research company chosen to help design and administer the trial, based on the questions included, the sample group targeted and the company's guidance and experience.

7.3.2 Interviews and focus groups

For more detailed understanding of participants' thoughts, feelings and experiences of PCA and the trial experience, more open-ended investigation methods are preferred. The key

methods available are either a focus group, where a small group of participants discuss particular topics, or an individual face-to-face interview between a researcher and participant. These methods allow participants much more freedom of expression, with less danger that the agenda is set solely by the researcher. Participants have more time to think about and discuss issues in depth. The richness of participants' experience of PCA, their reactions and reflections can be gathered and analysed in considerable detail.

However, these methods do have some disadvantages. They are more time-consuming and costly than other research methods and analysis takes longer to complete. The results are less 'objective' than from a closed questionnaire, in that the participants' responses may be more influenced, for example, by their relationship with the researcher, how they wish to present themselves or the interactions between individuals within a focus group. For individual interviews, the analyst's summary will also be affected by his/her experience of the interview. The outcome of the interviews will be open to different interpretations. Best practice research protocols can be used to minimise these problems.

Individual interviews and focus groups will be a key element in gaining the depth of knowledge about PCA a trial hopes to uncover. While it may not be possible to interview all participants face-to-face, a substantial number of interviews should be undertaken in any trial, with some participants being interviewed on more than one occasion to understand how their views and perceptions of PCA change during the trial.

7.3.3 Internet-based data collection

There is a good case to be made for recruiting participants who have regular access to an internet connection, and for using this as the key communication and data collection route. Using computer-based forms, data gathering and data entry will be quicker (for the research team) than telephone or paper methods. Email is a convenient way of reminding participants to fill out forms, complete surveys and for providing them with feedback on their carbon account. The internet can remove participant response bias that might be exhibited in face-to-face or telephone interactions with researchers. Furthermore, there are new developments in internet-based research, for example, it is possible to show video-clips with demonstrations to convey instructions to participants about what they are being asked to do.

ECI, as part of UKERC, is currently developing and testing a software tool, called 'imeasure', which has been designed to engage and provide feedback to users about their energy use and consequent carbon emissions. Imeasure allows users to input weekly energy meter readings and to get feedback on their total energy use and carbon emissions to date, to see how their emissions have changed over time and to compare themselves with specific groups of other users. It can provide feedback to users immediately when they enter their data, allows them to access their 'carbon account' as often as they wish, and enables them to view their data in different formats. Future developments of this tool will add to its interactivity and scope. Imeasure is one implementation of the 'next generation' of carbon calculators (Bottrill 2007) and it is the sort of tool which would be a vital part of an internet-based PCA trial.

However, in addition to the opportunities it opens up, there are some disadvantages of using the internet. Most importantly, use of the internet and home access to the internet is very unevenly distributed within the population. The latest available data for GB internet access showed that 57% of households had access at home between January and April 2006 (with 95% confidence limits between 54 and 61%) (National Statistics 2006). There are regional differences in access, for example, 66% of households in the south east of England had access compared with 48% in Scotland. The same survey asked participants whether they had accessed the internet within the last three months (regardless of whether they had internet access at home). In that period, more men than women had used the internet: 65% compared with 55%. There was a much greater divide by age, with 83% of the 16-24 age group having accessed the internet compared with 15% of the 65+ age group (82% of this age group have never used the internet). The higher an individual's income, the more likely he or she is to have accessed the internet. In the lowest income group (<£10,400), 51% of people have never used the internet, compared with just 6% in the highest income group (>£36,400). Therefore a trial which requires use of the internet by participants will be sampling from a population biased towards younger, richer, male respondents living in the south east of England. Groups who might be thought of as vulnerable, particularly the elderly and those living on low incomes, would be under-represented.

To decide whether to use the internet for communication with participants, it is worth considering if it would be possible to run the trial without internet access. Probably the only aspect of the trial which would not be

feasible without internet access would be the inclusion of virtual carbon trading. Otherwise, information could be gathered and feedback provided by a variety of routes (by post, telephone, in person) – which while they will not be as quick or convenient as the internet could work well. Given the advantages of using the internet, particularly the instant feedback on energy consumption and carbon emissions it enables, the trial designs presented in Section 8 will use the internet as a communication route, except where this would compromise recruiting a suitable sample of participants.

7.3.4 Collecting energy and travel data

One of the key research tasks in the trial is to collect monthly energy use and travel data from participants. As with other data, there are a number of ways in which participants could return this information: by paper, telephone, SMS text message, internet database, in person to a researcher / community worker. To a large extent, the method of communication will be determined by the characteristics of the sample recruited. For a trial being carried out via the internet, it would be easiest for participants to input their data direct into their own carbon account, being prompted by email to do so. A trial which involved people without internet access might offer participants a choice of telephone prompts and reporting or contact by post. If a trial included particularly vulnerable groups, who found meter reading difficult (e.g. people with mobility / eyesight difficulties) a support worker could help read meters and gather other data. If it was anticipated that participants needed this level of support, the trial would involve geographical clustering of participants to enable support to be given cost-effectively. However the data were collected, they would be input into a database which would automatically check

for the plausibility and consistency of data and alert researchers if there appeared to be errors in meter / odometer readings.

The imeasure software tool mentioned in the previous section, or something similar, would be very useful for both collecting data and providing feedback within an internet-based PCA trial. Even participants without home internet access, and who provide their data by other routes, could have an internet carbon account which they access from time to time as an additional form of feedback.

7.4 Recruitment and retention of participants

Recruitment and retention of participants is a key issue in any study, particularly a longitudinal study such as this one. These issues, particularly retention, were consistently flagged by the experts consulted during this study as core to designing a PCA trial. Earlier discussions around sampling and information gathering have already stressed the need to bear in mind the participants' experience of the trial. Recruiting and retaining a large sample could be challenging, especially if more complex aspects of a PCA are tested, such as the development of carbon trading strategies.

There are two strategies available to increase success with recruitment and retention:

1. reduce the 'costs' of taking part in the trial
2. increase the 'benefits' of taking part in the trial

7.4.1 Reducing the costs

Reducing the costs is a shorthand way of saying that the trial needs to be as easy as possible for participants to take part in. Making the trial attractive to participants will include the

following:

- Providing clear instructions and communications throughout the trial, in particular, participants must be very clear what is expected of them during the course of the year;
- Contacting participants in a way that suits them best: by phone / internet / mail etc. and providing helpful reminders when data is due back from participants;
- Offering support to participants via telephone help-lines or personal visits where appropriate;
- Asking the minimum number of research questions and minimising participants' time commitment consistent with the aims of the research.

7.4.2 Increasing the benefits

Experienced researchers have told us that although many trials offer financial payments, they feel participants' key reasons for joining a trial are largely altruistic. Participants feel that by being involved they are benefiting wider society or adding to research knowledge. It is important that the research project recognises and responds to these motivations.

The key benefits the trials can provide to participants are:

1. knowledge that they are contributing to understanding in a major policy area;
2. guarantees that their experiences and views are valued and will be taken full account of in the research (face-to-face contact and interviews may help with this);
3. feedback on their own carbon emissions and lifestyles, to help them understand their carbon footprint and how (or if) it changed over the course of the trial;
4. financial rewards for taking part in or completing the trial.

For all trial options some level of financial payment will be appropriate. It is important to give consideration of how to structure that compensation. For example, the level of payment must not be so high that it distorts sample recruitment. Three types of compensation commonly used in field studies are – 1) regular payments, in the order of £10–£20 per month per participant often given in the form of a retail voucher, 2) a lump-sum payment upon completion, and 3) entering a big prize draw. The most appropriate type of payment may depend on the sample type recruited. In terms of project costs, all could be similar.

7.4.3 Retention rates

However well designed, any trial will have a drop-out rate as people decide not to continue being involved. Past experience suggests there could be high attrition rates in a PCA trial. For example, a study carried out on food purchasing habits, where people were asked to complete short questionnaires weekly for two months, began with 50 participants but only collected data for the whole period for 20 participants (Gatersleben 2007). The RESOLVE project which is underway at Surrey University is planning to recruit several hundred households in order to ensure that one hundred households will still be involved in the project in two years time. It is hoped that by learning from experience and by pre-testing aspects of trial design, a PCA trial might be able to achieve a drop-out rate of only 50%, so that twice as many participants are recruited as are involved by the end of the study. However, this may be optimistic.

It has been challenging trying to estimate how difficult it will be to recruit and retain

participants for a trial. Some experienced researchers have told us they would expect it to be difficult, and that recruiting several hundred participants would be an extremely lengthy and expensive process. Others we have consulted have expressed fewer concerns. Retention rates may be lower for vulnerable groups, but no firm data have been found on this. The practical knowledge about recruitment and retention of participants in a longitudinal study such as this, seems to reside in experts' heads rather than in the literature. This makes it particularly difficult to judge between different opinions.

To prepare for participant drop-out any trial should first plan on over-recruiting and second should capture data from participants along the process so that if they do leave the trial early, they will still have provided some useful information. There is a strong danger that as drop-out rates increase, the remaining sample of participants becomes increasingly atypical of both the original group recruited and the wider population. PCA trials should make every effort to encourage good retention rates (using the tactics suggested above), primarily in order to increase the effectiveness of research outcomes, but also to control costs. In addition, it would be extremely valuable to hold 'exit interviews' with participants who leave the study early. These interviews could discover why participants no longer wanted to continue in the trial, and particularly whether aspects of PCA had influenced their decision to exit.

7.5 Summary: A PCA template for trials

The key concern in designing a trial must be to ensure that it effectively communicates the basic principles of the PCA scheme to participants so that good attitudinal and

behavioural data about their experience of the scheme can be collected. As mentioned earlier, the trial will seek to replicate a particular version of PCA, some aspects of which may differ from a future introduction of PCA nationally. Table 4 summarises the standard PCA template for proposed research trials based on the preceding discussions.

The feedback received from the second workshop for this study, in particular from community group organisers, was that a standard template would be helpful guidance for community based experiments with PCA. Hopefully Table 4 can fulfil this function.

Table 4: The PCA template for trials

| Parameter | Parameter setting |
|-------------------------------|---|
| Time scale | One year |
| Administration | <ul style="list-style-type: none"> • Internet-based: trial managed through specially designed web tool. Each participant sets up a carbon account from which to manage their carbon allowance. • Non-Internet based: trial managed through submitting and receiving information via telephone and mail. |
| Setting carbon allowance | PCA is based on the UK per capita average annual emissions for home energy, private vehicle and air travel. |
| Allocation carbon allowance | Adults receive equal allowance and children receive one third to half an adult allowance. |
| Participation | Only one person per household has to be an active participant. |
| Frequency carbon units issued | The total carbon allowance is given to participants at the start of the trial. |
| Surrendering carbon units | The number of carbon units surrendered from the carbon allowance is based on monthly household energy meter readings, vehicle odometer readings and miles flown. |
| Carbon trading | More fully included in an internet-based trial. Otherwise it may be limited to 'what if' questions with participants at the end of the trial. |
| Information feedback | Participants receive monthly information about the amount of energy used, carbon emitted deducted from allowance, monetary value of allowance and cost of carbon units. |
| Incentives/penalties | No real money is used – trading and feedback is based on play money. |

8. Potential trial designs

Rather than focus on one trial, we have outlined three different research trials:

- PCA Basic
- PCA Community
- PCA Comparator

All the trials have been designed to answer the research questions listed in Table 1 and will use the PCA template (Table 4). PCA Basic – as the name suggests – is the most modest trial in terms of participant numbers and costs that we can envisage which would answer the key research questions. PCA Community works with particular communities and greater participant numbers to answer the same questions within specific groups of the population. PCA Comparator broadens the research scope to compare PCA with other possible carbon reduction policies. Each of the options takes a different approach to participant numbers and sampling strategy, which necessarily alters how the results can be interpreted.

The purpose of outlining three options is to provide guidance about the insights available from different designs. Elements from each of the trial options could be combined to run one larger trial, sample sizes could be altered or research priorities varied. These trials are designed to illustrate a range of options and are not presented as the only possible choices. Section 8.4 outlines some suggestions for alternative trial designs presented by reviewers.

For each trial, the number of participants quoted is the number remaining in the trial until the end. Two or three times this number may need to be recruited initially.

In this section, each of the options is outlined in terms of the trial design, the benefits and limitations of the trial and its approximate

costs and time scale. Note that all costs are broad estimates and are provided for illustration purposes only. Staff salaries have been multiplied by 2.5 to allow for typical institutional overheads. The cost estimates included in no way constitute a bid by ECI or UKERC.

8.1 PCA Basic

PCA Basic is the smallest-scale implementation of a trial which would still give worthwhile research results. It would have 100 participants. The sample would be recruited on a stratified or quota basis with respect to demographic characteristics, so that demographic diversity could be achieved. The sample size would be too small to be representative of the UK population, but as discussed earlier, with this type of trial there are inherent limitations on the degree to which a representative set of participants can be recruited.

In this small-scale trial, participants' experience of the PCA should be uniform, to make it easier to analyse data from the trial and draw stronger findings. Participants should have the same data reporting process (e.g. via mail or telephone) and the same research process in terms of questionnaires and interviews. Given the desire to include a demographically diverse group of participants, internet access and on-line carbon accounts would not be used in this trial. Inevitably this will reduce researchers' ability to include the trading elements of PCA in the trial.

The sample is a manageable size and, it will probably be most convenient to recruit participants from a small geographic area. The small size of the group will make it more cost-effective to use interview techniques across the whole sample to gather information about

participants' reactions and response to a PCA. This is likely to result in richer data because there is more flexibility to capture information beyond the boundaries of a fixed questionnaire.

PCA Basic (Table 5) would run over two and a half years. There would be a nine month design and testing phase, 15 months for running the experiment (the extra three months is added for flexibility should recruitment prove problematic), and six months for the analysis, writing up and dissemination phase.

PCA Basic would be somewhat quicker and definitely cheaper than the other trial options outlined. However, having a smaller sample size and excluding on-line carbon management and trading possibilities clearly limits some of the conclusions that could be drawn from the study. Nevertheless, it does represent a cost-effective research option.

Although the authors feel that PCA Basic incorporates the idea of trading sufficiently, some reviewers of an earlier draft of this report did not agree. Their view is that unless trading is included in any trial as comprehensively as possible, what is actually being trialled is not sufficiently like 'real' PCA for the trial to be valid. Insights from the trial will not be specific to PCA because trading is an inherent part of PCA. For these reviewers, the carbon trading system proposed in PCA Community and PCA Comparator would be an essential part of any trial, however small.

An alternative research design would be to undertake this same trial format, using a group of 'future featurers' with internet access, and include trading. This would deliver results requiring different interpretation from the original PCA Basic and would cost £50,000 more (see Table 6).

Table 5: Estimated cost of PCA Basic

| | Full time cost per year (£k) | Total project cost (£k) | Cost notes |
|---|------------------------------|-------------------------|-------------------|
| People | | | |
| Project manager | 113 | 56 | 1 day per week |
| Lead researcher (PCA specialist) | 88 | 219 | Full time |
| Research assistant | 75 | 94 | 2.5 days per week |
| Social scientist (survey methodology) | 75 | 75 | 1 year staff time |
| Services | | | |
| Sample recruitment and questionnaire delivery | | 25 | |
| Publicity and printing final report | | 15 | |
| Support costs, postage, computers, travel etc | | 15 | |
| TOTAL | | 500 | |

8.2 PCA Community

PCA Community is a larger scale trial than PCA Basic and aims to recruit a variety of 'vulnerable' groups into the trial, including low-income and elderly households, as well as a more general sample of the population. Running a trial with these types of groups would be valuable because for a PCA scheme to be publicly and politically acceptable it must be known how these vulnerable groups will respond.

PCA Community could be run with three different groups of 200 participants in parallel: a low-income group, an elderly group, a group representing the general population. Alternatively, smaller group sizes could be chosen, and a wider variety of vulnerable groups represented. This trial design could work equally well with other vulnerable groups such as disabled people, ethnic minority groups, single parent families and rural communities.

The PCA Basic approach of uniformity of trial experience and exclusion of internet access would probably be used for the low-income and elderly groups, as we know these groups are unlikely to have internet access at home. Alternatively, community workers might be able to facilitate internet access for these vulnerable groups. For the general population group, or for vulnerable groups likely to have average levels of internet access, the internet would be the preferred method of communication so that this trial could include on-line carbon management and trading. It would be possible either to only recruit people with internet access at home for the general group, or to use internet trading with the sub-sample who do have internet access.

In part because of the needs of the vulnerable groups, this study is likely to involve a high

degree of face-to-face interviews and focus group research techniques, rather than telephone or postal surveys. The project costs include the need for community workers who would be able to support participants during the study, perhaps with tasks such as meter reading, or filling in forms. The community workers would also be able to help recruit participants to the study. Because participants will require personal support, recruitment is likely to be done within limited geographical areas. Community organisations it might be possible to work with include housing associations, sheltered housing groups NGOs (e.g. Help the Aged) and CRAGs and local authorities.

Different vulnerable groups will require different types of support to enable them to fully participate within the study. Researchers would need to take advice from community organisations on this, and to pre-test different support mechanisms (e.g. large-print material for the visually impaired, simple text material for people with literacy difficulties, home visits). Finding out what support is needed, and researching how it is best delivered, would become part of the trial study.

PCA Community would run over three years. There would be a nine month design and testing phase, 18 months for running the experiment (the extra six months is added for flexibility should recruitment prove problematic), and six months for the analysis, writing up and dissemination phase.

In order to enable on-line energy use reporting, carbon accounts, instant feedback and carbon trading it will be necessary to develop a suitable web site for the project. ECI, as part of UKERC, is part-way through the design and testing of such a tool which could be adapted for trial purposes.

Table 6: Estimated cost of PCA Community

| | Full time cost per year (£k) | Total project cost (£k) | Cost notes |
|--|------------------------------|-------------------------|--------------------|
| People | | | |
| Project manager | 113 | 135 | 2 days per week |
| Lead researcher (PCA specialist) | 88 | 263 | Full time |
| Research assistant | 75 | 113 | 2.5 days per week |
| Social scientist (survey methodology) | 75 | 75 | 1 year staff time |
| Community worker | 63 | 125 | 2 years staff time |
| Services | | | |
| Web site design and support | | 50 | |
| Sample recruitment and questionnaire delivery | | 100 | |
| Publicity and printing final report | | 20 | |
| Support costs, postage, computers, travel etc. | | 20 | |
| TOTAL | | 900 | |

However, included here is an estimate of the full cost from the start of development.

This trial option will be able to present some participants with a fuller vision of the PCA concept than in PCA Basic and give them the opportunity to experiment with the tradable features of the allowance. For example, to sell surplus carbon units or to buy additional carbon units and see how this affects their carbon balance. Most importantly, it will focus attention on vulnerable groups who are the object of much social and political concern, and discover whether they have a more negative experience of PCA than the general population.

8.3 PCA Comparator

The aim of PCA Comparator is to determine if PCA elicits a behavioural or psychological response that differs from that of two

alternative policy instruments: carbon taxation and providing enhanced energy use and carbon emissions feedback. The findings of this study would go beyond the research questions identified in Table 1. Some of the contributors to this study felt strongly that a comparative research trial would be of much greater value and provide results relevant to a wider audience than one which investigated PCA alone – this is the reason PCA Comparator is presented as an option.

In order to compare PCA with other policies, a large sample group would have to be recruited and participants randomly allocated to different ‘treatments’ within the trial. Allowing participants to select an option they favour or oppose could distort results.

The numbers of people in each group must be large enough so that any differences between the treatments can be detected

in a statistically robust way. In order to determine sample sizes, it will be necessary to hypothesise likely differences between groups in terms of some key measurements – e.g. energy savings, behaviour changes, attitudinal variables, psychological reactions to the trials. Statistical analysis can be carried out to determine what minimum sample size would be needed in order to detect these differences at, say, the 95% confidence level. This detailed level of experimental design will need to be carried out as part of the trial study (rather than within this report). For the purposes of costing, it is assumed that each group will contain 200 participants.

PCA Comparator proposes trialling three different policy options: information feedback only; a price signal with information feedback (effectively a construction of how a carbon tax might work); PCA with trading available. In order to make the study design more robust, a control group could also be employed.

The control and three treatments detailed:
Group A (optional): Control – participants are questioned about their energy and environmental attitudes and their annual carbon emissions is collected (based on meter and odometer reading taken at the beginning and end of the trial period as well as recollection of flights taken). The purpose of the control group would be to pick up general attitudes and behaviour about energy and carbon emissions given the current policy landscape and media coverage of the issues.

Group B: Information feedback only – participants report energy use data monthly using the same Internet tool as Group C and D. Participants are given information about the quantity of energy used and carbon emitted.

Participants report energy use data using the same on-line tool as Group C and D.

Group C: A price signal with information feedback to mimic carbon taxation – participants report energy use, receive information feedback about the quantity of energy used and carbon emitted via the on-line tool. In addition to this information participants would be given a price of carbon – the price would be presented as a fixed percentage of energy expenditure throughout the trial. The carbon price should be set at a similar level to the price of carbon in the PCA treatment. Every time a participant reported their energy use (monthly) they would be told the carbon cost of that use. If a carbon tax were implemented it could be introduced as revenue neutral and therefore participants should be given an indication how other taxes might fall. This information could simply be presented at the beginning of the study. There remain many questions about how and whether a sufficiently realistic experience of taxation can be provided for participants. To find the answers, a similar process of discussion and research may be required as has been undertaken in this study for PCA. However, the idea of trying to test taxation against PCA and information feedback options was proposed by more than one economist we consulted. Also, there is a branch of environmental economics (contingent valuation) which has investigated how to make ‘hypothetical markets’ as convincing as possible. Therefore, it is our assumption that it might well be possible to trial taxation in a meaningful way – but substantiating this assumption or elaborating further on how to trial carbon taxation is beyond the scope of this report.

Group D: PCA with trading available via an internet tool – All energy use reporting, information feedback and questionnaires will be internet-based in this trial. Face-to-face interviews will be undertaken for a sub-sample of the group.

A key advantage of this type of research design is that the findings will be valid in terms of the relative effectiveness of PCA, regardless of the nature of the sample and how representative it is of the wider population. Each experimental group will be drawn from the same sample. However, because all participants will need access to the internet, the PCA treatment group is likely to be less representative of the general population than is the case in PCA Basic. This will limit the interpretation of some of the data gained from the study.

PCA Comparator would run over three years. There would be a nine month design and testing

phase, 18 months for running the experiment (the extra six months is added for flexibility should recruitment prove problematic), and six months for the analysis, writing up and dissemination phase.

In order to properly design a trial version of the carbon taxation / financial incentive policy option, it will be necessary to have an economist as part of the research team. For both carbon trading and carbon taxation the conditions will be artificially set for the trial, because at the moment it is not clear the best ways in which to structure a downstream carbon market or a carbon taxation regime. Researchers will have to approximate carbon prices for both group C and D treatments, which will require careful consideration.

As for PCA Community, the cost of developing and supporting a web site to allow carbon trading is included.

Table 7: Estimated cost of PCA Comparator

| | Full time cost per year (£k) | Total project cost (£k) | Cost notes |
|--|------------------------------|-------------------------|---------------------|
| People | | | |
| Project manager | 113 | 135 | 2 days per week |
| Lead researcher (PCA specialist) | 88 | 263 | Full time |
| Research assistant | 75 | 225 | Full time |
| Social scientist (survey methodology) | 75 | 75 | 1 year staff time |
| Economist | 75 | 60 | 0.8 year staff time |
| Services | | | |
| Web site design and support | | 50 | |
| Sample recruitment and questionnaire delivery | | 100 | |
| Publicity and printing final report | | 20 | |
| Support costs, postage, computers, travel etc. | | 20 | |
| TOTAL | | 950 | |

Because two other policies are being tested in this trial, the results will be of interest to other research communities. Researchers interested in taxation / financial incentives to change behaviour, and those investigating smart metering / feedback should find the results valuable. This trial would be designed in collaboration with experts in those fields.

8.4 Progressing the trials

The trial options outlined are summarised in Table 8.

A number of reviewers of this report have proposed that a different combination of research elements from those set out in our three example trials would be optimum in terms of research results and value for money. Their suggestions include:

- All trials should include a trading element as fully as possible; PCA Basic should be re-designed on this basis;
- Rather than PCA Comparator, a better third option would be an expanded trial which included both trading with a greater number of general participants than PCA Basic, and the vulnerable groups element from PCA Community;
- A strong case can be made for running a trial using only future featurers.

Whatever its final design, undertaking a PCA trial is a major piece of research, and as identified above could cost between £500k and £950k. It would be unrealistic to expect a small-scale trial to be completed in less than two and a half years, with the larger-scale trials taking longer. There is no provision within the UKERC budget for undertaking a PCA trial. Therefore it will be necessary to seek research funding from new sources if a PCA trial is to go ahead. It is currently unclear what scale of resources, if any, Defra will commit to this area in future years. The most likely sources may be the UK Research Councils and government departments

either individually or in combination.

Alternatively, a PCA trial could be an option for UKERC phase 2, should that be funded (2009 onwards).

Any trial undertaken should involve an inter-disciplinary group of researchers to ensure a robust design and the appropriate expertise is available to analyse the findings. Some disciplines that would be beneficial in the core research team are energy policy, sociology, environmental psychology, economics, and political science. A reviewer has noted that the literature on energy and social psychology, which has not been accessed as part of this scoping study, would be valuable in informing a trial design. So it would be particularly important to include somebody expert in these topics within any research team.

Trials, particularly PCA Community and PCA Comparator, would benefit from the involvement of the wider research and NGO community. The workshops held during this study indicate a high level of interest in the idea of a PCA trial, and it is hoped this enthusiasm could be harnessed during a trial to generate more meaningful and widely useful results.

Finally, before a trial could be undertaken there would need to be further thinking and debate on a number of issues including: the use of control groups, involvement of market research skills, pre-testing aspects of the trial, incorporating learning from community-based trials, communicating and trialling the financial aspects of PCA, setting detailed boundaries for the carbon allowance, and setting an allowance for children.

Table 8: Summary of research trial options

| | PCA Basic | PCA Community | PCA Comparator |
|------------------|---------------------------|--|---|
| Sample size | 100 | 600+ | ≈ 800 |
| Time scale | 2.5 years | 3 years | 3 years |
| Approximate cost | £500,000 | £900,000 | £950,000 |
| Research focus | Key questions in Table 1. | Key questions in Table 1, with an additional focus on vulnerable groups. | Key questions in Table 1. Plus comparison between PCA, carbon taxation, and information feedback. |

9. Conclusions and recommendations

This study has suggested that a well-designed PCA trial can contribute unique quantitative and qualitative data which will answer key research questions about the effectiveness and social acceptability of PCA. A PCA trial will enable understanding of how people respond to the experience of living with a simulated PCA and how their attitudes and energy-related behaviour change. It will provide numerical data on carbon emissions profiles, capture unexpected reactions to PCA, test how people's views and behaviours vary with their personal circumstances and can be used to compare the effectiveness of PCA with other low carbon policies.

During the course of the study, the many challenges of replicating PCA in a trial study and of properly interpreting the data that will result from a trial have been identified. Despite the complexity inherent in running a PCA trial, none of the alternative research methods suggested can offer answers to many of the research questions a trial can address. A number of experts were consulted through the course of the project and although views varied on how to approach designing a PCA trial, most thought a well-designed trial would lead to beneficial insights about PCA.

In addition to the research benefits, there is also likely to be policy benefit in running a demonstration of PCA. Indeed, it may be impossible for PCA to be adopted as a policy option without such an example being available. It is also important to understand that informal PCA trials are already happening in the community and within organisations. The research community should be contributing to the learning available from these experiences, and providing a 'gold standard' research trial which can provide academically robust results.

The design of a trial and suitable research methods have been discussed in detail, drawing on both the literature and the experience of experts consulted during this study. These discussions have been used to identify both a clear set of key research questions and a template for PCA trials. Together these provide a firm basis for a future proposal for a trial study.

A PCA trial should be undertaken in the near future. At a minimum this would be PCA Basic, a study which would last two and half years and cost approximately £500,000. However, by extending the scope of the study, in a way suggested by PCA Community and PCA Comparator, a wider range of research benefits could be achieved.

PCA is an important policy idea which is attracting a lot of public and political attention, but which is very much under-researched. Carrying out a trial is an important research route, amongst others, to learn more about this policy and to gain more general insights into individually-focused carbon reduction policies.

10. References

- Aldersey-Williams, H., J. Bound, et al., Eds. (1999). *The methods lab: user design for research*. London, Design for Ageing Network, Helen Hamlyn Research Centre.
- Anable, J., B. Lane, et al. (2006). *An evidence base review of public attitudes to climate change and transport behaviour*. London, Department for Transport.
- Anderson, K. and R. Starkey (2004). *Domestic tradable quotas: A policy instrument for the reduction of greenhouse gas emissions: An interim report*. Norwich, Tyndall Centre for Climate Change Research.
- Bottrill, C., Ed. (2006a). *Personal carbon trading: An exploratory research and policy workshop*. Workshop summary report. London, UK Energy Research Centre.
- Bottrill, C. (2006b). *Personal carbon trading: the case for excluding ground public transport*. London, UK Energy Research Centre.
- Bottrill, C. (2006c). *Are we wasting the web?* Oxford, Environmental Change Institute, University of Oxford: 32.
- Bottrill, C. (2007). "Internet-based tools for behaviour change." *Proceedings of the ECEEE 2007 summer study*, Cote d'Azur, France.
- Brand, C. (2006). *Personal transport and climate change: exploring climate change emissions from personal travel activity of individuals and households*. Oxford University Centre for the Environment. Oxford, Oxford University. Unpublished PhD Thesis
- Castle, B. (2007). *Discussion about RSA work plan*. Personal communication, 31 October 2007.
- Clarkson, R. and K. Deyes (2002). *Estimating the social cost of carbon emissions*. Government Economic Service working paper 140. London, HM Treasury and DEFRA.
- Darby, S. (2006). *The effectiveness of feedback on energy consumption: A review for DEFRA of the literature on metering, billing and direct displays*. Oxford, Environmental Change Institute, University of Oxford.
- DEFRA (2007). *e-Digest Statistics about: Climate change*. Published on the web: <http://www.defra.gov.uk/environment/statistics/globalatmos/gagccukem.htm> (accessed July 2007), Department of the Environment, Food and Rural Affairs.
- Dresner, S. and P. Ekins (2004). *The distributional impacts of economic instruments to limit greenhouse gas emissions from transport*. London, Policy Studies Institute. PSI Research discussion paper 19.
- Ekins, P. and S. Dresner (2004). *Green taxes and charges: reducing their impact on low-income households*. York, Joseph Rowntree Foundation
- Elderkin, S. (2007). *Comments on economic aspects of PCA*. Personal communication, 19 September 2007.
- Fawcett, T. (2005). *Investigating carbon rationing as a policy for reducing carbon dioxide emissions from UK household energy use*. The Bartlett Faculty of the Built Environment, University College London. Unpublished PhD thesis.
- Fawcett, T. (2005). *Route map for research into personal carbon allowances*. Oxford, UKERC / Environmental Change Institute, University of Oxford.
- Fleming, D. (2005). *Domestic tradable quotas: A practical policy response to climate change and oil depletion*. London.
- Gatersleben, B. (2007). *Research experience of food diaries*. Personal communication, 26 September 2007.

Global Action Plan (undated). Changing environmental behaviour: A review of evidence from Global Action Plan. London, Global Action Plan.

Greenall, R. (2007). "8am. Shower. Save the Water. Save the Planet." BBC News Magazine. Available on the web: <http://news.bbc.co.uk/1/hi/magazine/6635759.stm> [accessed 24 May 2007].

Hillman, M. and T. Fawcett (2004). How we can save the planet. London, Penguin.

IPCC (2007). Climate change 2007: The physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds)]. Cambridge, UK and New York, USA, Cambridge University Press.

Keay-Bright, S. and T. Fawcett, Eds. (2005). Taxing and trading: Debating options for carbon reduction. Meeting report. London, UK Energy Research Centre.

Keirstead, J. and B. Boardman (2005). Response to Ofreg consultation I23/05: the regulatory implications of domestic-scale microgeneration. Oxford, Environmental Change Institute, University of Oxford.

Low, R. (2005). An investigation into the public acceptability of the personal carbon allowances proposal for reducing personal greenhouse gas emissions. Edinburgh, Edinburgh University. Unpublished MSc thesis.

Meyer, A. (2000). Contraction and convergence: the global solution to climate change. Totnes, UK, Green Books.

Miliband, D. (2006). Red-green renewal: the future of New Labour. Speech to the Fabian Society, 14 Dec 2006. London, Published on the web: http://www.fabian-society.org.uk/press_office/newssearch.asp?newsID=579.

National Statistics (2006). "Internet access, households and individuals." First Release. London, National Statistics.

Redgrove, Z. and S. Roberts (2007). Making carbon personal? A snapshot of community initiatives, May 2007. Bristol, Centre for Sustainable Energy.

Roberts, S. and J. Thumim (2006). A rough guide to individual carbon trading: the ideas, the issues and the next steps. Bristol and London, Centre for Sustainable Energy and DEFRA.

RSA (2007). Personal carbon trading: a fair way to reduce our carbon footprints? Published on the web: http://www.rsacarbonlimited.org/uploads/documents/RSA_PersonalCarbonTrading-ACommunityPerspective_25.pdf, Royal Society of Arts.

Sanderson, I. (2002). "Evaluation, policy learning and evidence-based policy making." Public Administration 80(1): 1-22.

Slavin, T. (2007). Carbon plans that make you cut down. The Observer. London: 13.

Starkey, R. and K. Anderson (2005). Domestic tradable quotas: A policy instrument for the reduction of greenhouse gas emissions. Norwich, Tyndall Centre for Climate Change Research.

Sustainable Development Commission (2005). Annual Review 2005-2006: On the Move. London, Sustainable Development Commission.

Taylor, K. (2007). "How to cut your carbon footprint in ten easy steps." Big Issue in Scotland.

Wickstrom, G. and T. Bendix (2000). "The 'Hawthorne effect' - what did the original Hawthorne studies actually show?" Scandinavian journal of work, environment and health 26(4): 363-7.

Appendix A: Workshop attendees and experts consulted during the project

Workshop 1 – December 13th, 2006

Advisory group

Dr. George Smith, social scientist, Oxford University

Professor Tom Snijders, statistician, Oxford University

Dr Sarah Darby, Oxford University

Workshop 2 – February 14th, 2007

Advisory Group (except Simon Roberts)

Keith Boxer, Manchester Knowledge Capital

Garry Charnock, Ashton-Hayes, Carbon Neutral Project

Graham Bennett, Catch the Vision

Simon Gerrard, CRED, East Anglia

Giles Gibbons, Good Business

Martin Hodson, SAGE

Greg King, Sustrans

Matt Prescott, RSA

Trewin Restorick, Global Action Plan

Lucy Stone, RSA

Interviewed

Oxford University

Dr. Marcel Fafchamps, economist

Colin Mills, social scientist

Dr. Cameron Hepburn, economist

Surrey University

Dr. Birgitta Gatersleben, social scientist

Dr. Rachel Muckle, social scientist

University of East Anglia

Professor Jacquie Burgess, social scientist

Dr Irene Lorenzoni, social scientist

Dr. Mike Nye, social scientist

Dr. Gill Seyfang, social scientist

Other

Helen Champion, Defra

Robin Sadler, New Perspectives

Tom Shread, ACNielsen

Appendix B: Matrix of PCA variables

Table A1: Matrix of trial options (in each column select a variable – they are independent of each other)

| General characteristics | | | | | Allowance details | | | | |
|-------------------------|-----------|---------------------------|--|----------------|------------------------------------|---|--------------------------------|----------------------|---|
| Scale | Length | Data from previous year | Participation | Managed | Number of individuals in the trial | Allowance allocation | Basis of allowance allocation | Frequency of issuing | Second trial year |
| national | 6 months | Known | Individuals | Paper based | < 100 | Adults only, equal. No compensation with households with children. | National per capita emissions | Weekly | Allowance remains the same |
| regional | 1 years | Unknown but estimated | Individuals, but can sign up whole household | Internet based | 100 - 500 | Adults only, equal. Additional child benefit given to households with dependent children | Regional per capita emissions | Monthly | Allowance reduced |
| local | 2 years | Unknown but not estimated | All household members | Both | 500 - 1000 | Adults only, equal & partial allowance given to children | Trial group average per capita | Quarterly | Not applicable because trial is run for a year or less. |
| | > 2 years | | | | > 1000 | Adults only, adjusted allowance for special needs groups (i.e. households using oil/coal for heating, single parents, disabled) | | Annually | |

Table A1: Matrix of trial options (independent of each other) continued

| Home energy use | | Transport | | | Trading | | Penalties | | Verification | Compensation |
|--|---|--------------------------------|-------------------------------|--------------------------------------|-----------------------------------|--|--|---|---|---|
| Fuels included | Electricity | Green electricity status | Fuels included | Public transport | Air travel | Overall | Incentives | Penalties | Verification | Compensation |
| All fossil fuels – i.e. gas, oil, LPG and coal | National carbon intensity figure | Green electricity included | petrol, diesel, LPG purchases | Public ground transport | All flights included | Selling, buying and saving allowed throughout the trial | Participants financially rewarded if they have surplus carbon units at the end of the trial. A price per kilo of carbon is set from the beginning of the trial | Over-emitters do not incur a real financial cost | None of the participants are independently verified. | A reward is given for completing the trial (e.g. £50 voucher) |
| | Carbon intensity varies by energy company | Green electricity not included | | Public ground transport not included | Only UK domestic flights included | Selling and buying not allowed during the trial. Balance settled at the end. | A community fund is set up with all the carbon saved equating to money that will be spent on a community investment | Over-emitters do incur a cost. A price per kilo of carbon is set from the beginning of the trial. | A proportion of the participants are independently verified. This involves submitting meter readings and MOT bills. | A reward is not given for completing the trial |
| | | | | | Only short haul flights included | Explicit trading not part of the trial | All participants receive a lump sum or vouchers for participating through until the end of the trial | Over-emitters do incur a cost, but a cap is set. A price per kilo of carbon is set from the beginning of the trial. | | |
| | | | | | Only long haul flights included | | | Over-emitters do incur a cost and no cap is set. A price per kilo of carbon is set from the beginning of the trial. | | |

Appendix C: Learning from existing and planned low carbon 'trials'

What communities need

The second workshop held during this project focussed on the involvement of communities in PCA trials. Some of the key points that came out of that meeting were:

- It would be beneficial if there was a PCA trial template with the key elements identified that all trials should contain. The design of the national scheme is not finalised therefore there should be variation between trials. Trial communities should have some flexibility on a few issues to ensure the trial fits with what is achievable and practical in their context. For PCA research trials it is probably best if communities have limited input in the design of the trial.
- Communities are placed differently to investigate PCA – therefore trial communities will be able to explore different research questions.
- Trials need to have different levels of breadth and depth. Some communities might be in a position to look at very specific PCA issues in-depth (e.g. Sustrans) whereas other community trials will need to be kept very simple and broad to appeal to a diverse group of participants.

However, despite the enthusiasm for PCA trialling within a wide range of communities, there was some concern that PCA could introduce a tension between the community and the individual. Running a PCA trial might undermine community building unless it explicitly links benefits of trialling back to the community level. This could be a problem for PCA which is essentially a policy aimed at individuals rather than communities.

What researchers can provide

Two activities / tools which would be of benefit both to groups doing their own trials of PCA and to researchers have been identified:

- co-ordination between trials to improve the robustness of trials and to capture learning and insights
- tools to enable voluntary / other organisations' activities contribute to the overall research effort.

Both of these could be undertaken as part of any research contract to carry out a trial of PCA, or as a separate activity.

For the co-ordination facility, the obvious way to undertake it would be to have a web-based database which gives information on all known existing 'trials' which are linked to PCA. Creating a web site is relatively easy. The difficult part of the activity will be both to collect this information in the first place, to keep it updated and relevant, to alert interested groups that it is available and create a network of users (Bottrill 2006c). For the web-site to fulfil its purpose it will need to be relevant to and valued by both community groups and researchers. Work on compiling a list of community-based carbon reduction trials is currently being undertaken by CSE. This could form the basis of a web database.

The tools which voluntary groups could make use of would include:

- A checklist of minimum requirements for any trial to contribute further knowledge about PCA
- Recommendations for how to carry out a workplace / community-based trial
- Carbon calculations and provision of feedback advice – possibly in the form of software (currently being developed by ECI as part of UKERC).

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The views expressed are those of the authors and are not necessarily shared by the advisory committee or others who have kindly given their time to the project.



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