Internet-based tools for behaviour change

Catherine Bottrill
Environmental Change Institute
Oxford Unversity Centre for the Environment
United Kingdom
Catherine.bottrill@eci.ox.ac.uk

Keywords
carbon calculators, personal carbon emissions, energy use, transport, Internet, information feedback

Abstract
Internet-based carbon calculators have the potential to be powerful tools for helping people to understand their personal energy use derived from fossil fuels and to take action to reduce the related carbon emissions. This paper reviews twenty-three calculators concluding that in most cases this environmental learning tool is falling short of giving people the ability to accurately monitor their energy use; to receive meaningful feedback and guidance for altering their energy use; or to connect with others also going through the same learning process of saving energy and conserving carbon. This paper presents the findings of research into the accuracy and effectiveness of carbon calculators. Based on the assessment of the calculators the paper discusses the opportunities Internet technology could be offering for engagement, communication, encouragement and guidance on low-carbon lifestyle choices. Finally, recommendations are made for the development of accurate, informative and social Internet-based carbon calculators.

Introduction
The development of a low carbon energy society necessitates that all actors take responsibility for the greenhouse gas emissions they release into the atmosphere from burning fossil-fuels. To achieve this objective effectively, actors need accurate and appropriate information tools to help them make informed investment decisions and behavioural choices. These information tools should give actors the ability to identify, quantify and monitor greenhouse gas emissions as well as to access meaningful feedback on opportunities to reduce those emissions. The tools need to be designed to meet the specific needs of energy end-users, be they government, organisations, companies, or citizens.

The focus of this paper is to examine one particular information tool, commonly known as carbon calculator, which is aimed at individuals and households. A review of twenty-three Internet-based carbon calculators was undertaken in this study. Of the twenty-three calculator tools reviewed, fourteen were developed in the UK and ten in non-UK countries. All of the tools studied were available in English.

The review first evaluated the accuracy with which the calculators estimate personal carbon emissions and second assessed their effectiveness in supporting carbon learning. The latter assessment was performed by scoring each calculator using a common set of criteria. The findings of the review are presented and suggestions are put forth for developing the next generation of carbon calculator tools. The Environmental Change Institute is actively using the insights of the review to inform continuing work on carbon calculators.

Internet technology if successfully applied and used offers a powerful tool by which to support the learning, understanding and actions of people wanting to take responsibility for their carbon emissions. It is argued that for carbon calculators to be a more beneficial tool to people they need to be accurate, to allow on-going interaction, to be socially networked and to provide appropriate feedback on carbon reduction measures. If this is achieved calculators can support the key social learning processes of attention, retention, replication and motivation, as

described by behavioural psychologist Albert Bandura, a proponent of social learning theory (Bandura, 1977).

PERSONAL CARBON CALCULATORS

Carbon calculator tools have been developed by a wide variety of bodies including non-government organisations, commercial companies, government agencies, universities and media groups. Carbon calculators have been developed primarily to increase awareness of the connection between fossil fuel use and carbon emissions and/or to enable people to invest in carbon saving projects to offset their emissions. Personal carbon calculators are tools that aim to quantify the amount of carbon an individual or household emits into the atmosphere from either a specific fossil fuel energy-use or in total from a combination of activities requiring fossil fuel use. The majority of existing carbon calculators endeavour only to estimate the emissions from home energy and travel use. Calculators are mostly concerned with providing users with results of their per annum carbon emissions. There are a few calculators that attempt to estimate the embodied carbon emissions from the goods and services used by individuals, but this is limited because of the difficulty in calculating these sources of emissions with any accuracy.

Carbon Accuracy of Calculators

The accuracy with which carbon emissions are measured is important if people are to be able to benchmark and monitor the changes in their carbon emission profiles over time. Without being able to accurately quantify carbon emissions people will not be able to know if the technology investments and lifestyle changes they make are actually translating into any real carbon savings.

Carbon calculators typically involve users providing some general household information and then inputting more specific information about home energy and personal transport use for the year. The calculators translate the data provided into a quantity of energy for each activity and then multiply this by a corresponding carbon emission conversion factor to derive the carbon emissions generated by each activity. Once the carbon calculator has calculated the carbon emissions from each energy using activity, they are summed together to give a total annual carbon impact. Typically calculators use same emission conversion factors as the national governments use for their reporting – in the case of the UK this is the Digest of United Kingdom Energy Statistics. However, there can be variations between calculators in the emission factor used, this holds especially for electricity where the fuel mix for power generation changes and for aviation where there is not yet scientific consensus.

In nearly all cases carbon calculators give users an annual carbon emission result. However, this annual value is normally estimated from a single data entry per activity, which can represent a year, quarter, month or week of energy use. By only accepting one data input and assuming it to be the average rate of consumption means calculators can not take into consideration seasonal fluctuations and variations in lifestyle that affect home energy and travel use over the course of the year.

Calculators can be framed as either calculating carbon emissions for an individual, the household or both. Oftentimes calculators do one or the other. A calculator may ask the user for the number of people in the household, but this will not necessarily mean results are given in terms of per person emissions. Therefore, users have to be conscious when entering in data or interpreting results whether they are looking at carbon results for a single individual, or complete households.

The carbon accuracy of a carbon calculator depends on the type and quality of the data inputted. There are three types of data that calculators will commonly use to calculate the carbon emissions of an individual or household – 1) building fabric- and technology-based, 2) expenditure-based and 3) quantity-based. Oftentimes calculators will use a combination of each of these and will give users a choice in what format they want to input data.

The first data input type, building fabric and technology, is used to calculate the carbon emissions resulting from home energy use. The user is asked a series of questions, for instance, about their home's building fabric, space heating and water heating systems, and possibly lighting and appliance ownership. Calculators relying on this approach are not able to provide users with accurate carbon emission results because without information on actual energy behaviour the information is not sufficient.

The second data input type, energy expenditure, is commonly used by calculators to calculate the carbon emissions resulting from home energy use. Calculators evaluating carbon emissions on energy expenditure will ask users to input for example information on how much they spent by fuel type for the year, quarter, or month. This approach too is unlikely to be accurate in determining carbon emissions because it is very difficult to translate the amount of money paid for fuels and electricity accurately into the quantity of fuels and electricity consumed, as calculators do not know the tariff rates charged to the user by their energy company.

The third type of data input commonly offered by calculators is quantity-based information. There are two forms of quantity-based information; the first simply being the amount of energy used in terms of, for example, kilowatt hours of electricity, cubic feet of gas, and litres of petrol and the second specific to transport, is the distance travelled by different modes (either private or public). The quantity based approach especially in the first form has the potential to give users reasonably accurate carbon results.

Calculators offering the ability for users to input the quantity-based data for home energy typically suggest to users they refer to their energy bills for the information of how much energy their household has consumed over the month, quarter or year. In the UK, energy bills do provide this information, but it is often only an estimation of household energy consumption rather than the actual energy consumed by the household. Furthermore, in the UK energy companies only provide energy consumption information for the month or quarter that the bill is for. Users need to have a full year's worth of energy bills to have a reasonable estimate of their annual energy consumption.

Calculators that work with the second type of quantity-based data (i.e. the one specific to transport), use two alternative approaches for deriving the carbon emissions from private transport use. The first approach, and potentially most accurate, is

Table 1: Information and data inputted in each calculator

Area	Data input
General household information	4-person household terrace house built in late the 1970s - early 1980s 100 m^2 floor area gas central heating combi-boiler partial double glazing some energy efficient light bulbs grade A appliances.
Household energy consumption	Gas: 5,000 kWh or 158 thousand cubic feet or £ 375 per annum per person Electricity: 1,000 kWh or £ 300 per annum per person.
Transport use	Car: 1.4 litre petrol engine, 35 mpg, 10,000 km or 6250 miles per annum; public transport Train: 2,600 km or 1,625 miles per annum Flights: a return flight from London Heathrow Airport to New York JFK Airport – 11,082 km or 6,926 miles per annum or a return long-haul flight, or 16 hours flight time.
Other	For the US calculators the state of Maryland was used and for the Australian calculators the state of Queensland was used as the place of residence.

for users to input the number of litres of fuels they have used in driving their vehicle(s). This information is available to users on their receipts from purchasing petrol and some newer car models have gauges measuring fuel use. The drawback of this method is that to ensure the carbon accuracy the user would need to save and tally up a year's worth of receipts.

The second approach is to ask users to input information on the distance travelled over the last year. Sometimes UK calculators suggest to users to refer to their last MOT certificate, an annual requirement to ensure vehicles are road worthy in the UK, if they want a more accurate input for the number of miles they have driven in a year. The calculators use this data together with information about fuel type, vehicle type, engine size, and fuel efficiency. This approach is only able to users a theoretical estimation of transport carbon emissions, as it does not incorporate driving behaviour, which is a significant determinant of fuel consumption and therefore carbon emissions.

Also, the quantity-based approach is often used by calculators for calculating public transport and aviation emissions. Users input the distance travelled and then the calculator will use an average carbon emission factor for each transport mode to estimate the carbon emissions. This approach will not provide accurate estimates of transport carbon emissions, because in the case of public transport there are many altering factors including the mode, fuel type, fuel efficiency and passenger occupancy. Therefore, to simplify calculations the distance travelled by public transport is multiplied by an average carbon emission factor for the fleet. In the case of aviation there are further methodological issues in estimating the carbon impact of flying, as there is not yet scientific consensus on what and how to calculator aviation emissions' impact. As a result there is no clear standard methodology for calculating the emissions from flying, which as will be seen from the trialling of carbon calculators leads to significant discrepancies between calculator results.

In summary, there are a number of different approaches for calculating personal carbon emissions. The carbon accuracy of a carbon calculator will depends on the type and quality of the information inputted by the user. A carbon calculator can only be as good as the quality of the energy data inputted. A carbon emission profile drawn from actual energy use for home energy and personal transport will be the most accurate. Profiles calculated from actual consumption figures are able to capture personal and household energy-related behaviour. Carbon emission profiles derived from information on technology efficiencies, building fabric and energy expenditure will not be accurate as these are only theoretical proxies for consumption rates rather than actual use. Most people using carbon calculators will not realise the shortcomings of relying on theoretical estimations of energy use rather than actual energy use data. There are substantial challenges to making it easier for users to input actual energy use data, but the next generation of carbon calculator must help users overcome this barrier so that these tools can better help people learn and understand their carbon emissions. More on this issue will be discussed later in the paper.

METHODOLOGY FOR COMPARING THE CARBON ACCURACY OF CALCULATORS

Each calculator was trialled with the same user data, as far as possible, on the general household characteristics; home energy consumption; and travel use (refer to *table 1*). These data inputs were selected as they represent a plausible annual personal energy use profile of someone living in a major industrialised country. The limitation in this approach was that each calculator did not ask the same questions of users and seven of the calculators reviewed did not cover public transport. The aim of trialling each calculator was to be given an individual rather than a household carbon impact result, as this research is primarily concerned with personal carbon tools. However, it is acknowledge that the separation between personal and household energy use is a false distinction, as many home energy and transport decisions are made at the household level rather than the individual level.

For 17 of the 23 calculators reviewed it was possible to actually input the quantities of gas and electricity used in the home. However, because the aim of the trial was to get an individual rather than a household carbon result, it was often necessary to input a person energy-use based on the four-person household size. For all the calculators trialled private vehicle emissions were calculated by inputting information about the type of vehicle, fuel efficiency and/or engine size as well as distance

Table 2: summary of UK carbon calculator results

	Home	Car	Aviation	Train	Total
tonnes of carbon-dioxide (t CO_2)					
Mean	1.48	1.80	2.18	0.23	5.73
Standard deviation	0.19	0.33	2.08	0.29	2.12
Minimum	1.38	1.00	1.00	0.00	4.30
Maximum	2.00*	2.25	7.80	1.00*	11.59

Note: *BP calculator gave the max. for home and train carbon emissions, but this is not accurate as the result was <2 t CO2 and <1 t CO2 respectively.

travelled. For 22 of 23 calculators reviewed aviation and public transport emissions were all calculated on the basis of entering distance travelled information. The comparative analysis of carbon accuracy focuses on UK calculators because it is not possible to compare the non-UK calculators with each other or with UK calculators, as the carbon emission conversion factors differ. However, it was still valuable to trial the non-UK calculators, as this informed the second part of the review that was examining the effectiveness of calculators.

RESULTS OF CALCULATORS FOR CARBON ACCURACY

The detailed results of trialling the calculators are in table 3 – grouped by UK calculators and then non-UK calculators and within each group ranked from lowest to highest total carbon results. The mean personal carbon result for the UK calculators reviewed was 5.73 t CO_2 (with a standard deviation of ± 2.12 t CO_2), which is based on the amount of energy used at home, and for car, aviation and train travel (*table 2*). This figure is approximately the UK average for personal direct carbon emissions. The minimum carbon result for a UK calculator estimating an individual's home, car, aviation and train emissions was Carbon Neutral with 4.30 t CO_2 and the maximum was Resurgence with 11.59 t CO_2 (*table 3*).

The factor of two variation between the carbon results of UK calculators can mostly be explained by the different emission results given for the aviation (2.18 t CO_2 per person ± 2.08, Table 3 and Figure 1). The results for aviation vary so greatly because calculators use significantly different carbon emission conversion factors, as there is no scientifically agreed standard. Some calculators only calculate the carbon-dioxide emissions from flying whereas others try to factor in the radiative forcing effects from releasing greenhouse gas emissions at high altitude as well as plane passenger capacity and airplane type. The Atmosfair calculator uses the Intergovernmental Panel on Climate Change (IPCC) figure of 2.7 for radiative forcing, whereas others such as Climate Care double carbon-dioxide emissions in recognition that emissions emitted during flying have a greater impact than if released at ground level. (Dokeen et al., 1999; Jardine, 2005). Carbon Neutral, which gave the minimum carbon result for aviation did not say what emission conversion factor they use, but it looks probable that the calculator only counts the carbon-dioxide emissions and does not include any of the radiative forcing effects. Resurgence gave the maximum carbon result for aviation and this is because it is using the highest multiplier of 0.87 kg CO_2 for every mile flown. In both cases no reference was given for justifying the multiplier used.

The variation between the results given by the calculators for the private vehicle emissions, represented by the car (1.80 t CO_2/p ± 0.33, Table 2) is mostly due to the level of detail it was possible to specify about the vehicle engine size and its fuel efficiency. Twenty calculators enable users to input this type of information. Environmental Defense is an example of a calculator that only asks the user to indicate if the car is small, medium or large and then applies an average emission factor for that class of vehicle. As discussed earlier, in order to get an accurate carbon result for driving, which captures behaviour aspects of driving, the number of litres of fuel would need to be inputted into the calculator and only three calculators allow this - National Energy Foundation (NEF), COIN and Landcare Research.

There was hardly any variation in the results given by UK calculators for emissions from home energy. Half of the UK calculators gave a carbon result of 1.38 t CO_2 per person for home energy with a standard deviation of ± 0.19 t CO_2 per person (*table 2*). This was because for nearly all calculators it was possible to enter an annual quantity of gas and electricity use and these calculators in all likeliness use the UK government carbon emission conversion factor of 0.19 kg CO_2 per kilowatt hour. The variation in home carbon results more likely to be due to calculators using different carbon emission conversion factor for electricity or the calculator relying on energy expenditure information rather than a quantity of energy used. The UK government standard carbon emission conversion factor for electricity generation has been 0.43 kg CO_2 per kilowatt hour since 2000 (DUKES, 2006), however this is not really constant because there are changes in the fuel mix for electricity generation.

The calculators that gave slightly higher carbon results were those that either only gave the option for inputting energy expenditure (MSN-Estimator), used a high carbon emissions factor for electricity (for example COIN, with 0.5 kg CO_2 per kilowatt hour) or based carbon results only on building fabric and technology information (BP). Had annual home energy expenditure been the input then there is likely to have been a greater variation in home carbon results, as the calculators

Table 3: Carbon results of calculators

Organisation	Org. Type	Reason for tool	tonnes of carbon-dioxide (t CO_2) per person				
			Home	Car	Aviation	Trains	Total
UK carbon calculators							
Global Action Plan[1]	NGO	Educational	1.45	1.75	not working	0.20	3.40
Carbon Neutral	Business	Commercial	1.40	1.60	1.20	0.10	4.30
CO2 Balance	Business	Commercial	1.38	1.62	1.20	0.17	4.36
World Land Trust – Carbon Balance	Business	Commercial	1.38	1.80	1.20	na	4.38
MSN - Carbon Estimator	Media	Educational	1.70	1.80	1.00	0.00	4.50
Climate Care	Business	Commercial	1.38	1.86	1.54	na	4.78
RSA – CarbonDAQ[2]	NGO	Educational	1.38	1.86	1.54	na	4.78
South Hampton Sustainability Forum	NGO	Educational	1.39	2.06	1.24	0.16	4.86
National Energy Foundation (NEF)	NGO	Educational	1.38	2.25	2.01	0.16	5.80
BP[3]	Business	Educational	<2	~1	~1	<1	5.00
Bestfoot Forward – Stepwise	Business	Commercial	–	–	–	–	6.70
COIN	NGO	Educational	1.49	1.75	4.25	0.16	7.65
Resurgence	Media	Educational	1.38	2.25	7.80	0.16	11.59
Non-UK carbon calculators							
Atmosfair[4] (Germany)	Business	Commercial	na	na	3.48	na	3.48
Landcare Research (New Zealand)	NGO	Educational	1.11	2.00	1.23	0.09	4.43
Eco-Speed (German)	Business	Educational	2.09	0.95	1.86	0.17	4.90
Climate Crisis (USA)	NGO	Educational	–	–	–	na	5.85
The Climate Trust (USA)	Business	Commercial	1.99	1.57	3.04	na	6.60
Climate Friendly (Australia)	Business	Commercial	1.00	1.80	3.90	na	6.70
University of Sidney (Australia)	NGO	Educational	1.70	4.80	3.32	0.52	10.34
Environmental Defense (USA)	NGO	Educational	2.40	1.80	7.80	na	12.00
WRI - Safe Climate (USA)	NGO	Educational	–	–	–	–	12.70
Native Energy[5] (USA)	Business	Commercial	–	–	–	–	12.70

Key: na = not available, – = carbon emission breakdown not given in this format.
All the web-addresses of calculators are listed in the reference section.
1. The Global Action Plan aviation calculator was not working.
2. RSA-CarbonDAQ uses the calculator developed by Climate Care, but has created its own web-interface, which gives feedback in a different form.
3. BP does not give their results numerically, but in a pie and bar chart therefore exact figures had to be estimated from the information provided.
4. Atmosfair only calculates the carbon impact of aviation.
5. Native Energy uses the calculator as WRI- Safe Climate, but has expanded this to include public transport.

make different assumptions about tariff rates charged by energy companies.

Nine of the 23 calculators reviewed did not cover public transport emissions. This affected total carbon results slightly, as those calculators not covering public transport emissions naturally had lower totals. Of those calculators that did cover public transport the mean carbon result was 0.23 t CO_2 per person per year with a standard deviation of ± 0.29 (table 2). This is a distortion because BP did not give precise feedback on the emissions resulting from train use and the MSN calculator gave a result of 0 t CO_2 despite 50 km per week of train travel being inputted.

The calculators that have the potential to provide users with the most accurate annual personal carbon result are those that allow them to input actual energy and fuel consumption figures for home energy and private transport for the year. Calculators that provide users with this ability were National Energy Foundation, COIN, and Landcare. The National Energy Foundation and COIN calculators clearly indicated to users what emission conversion factors were being used. The calculator that is prob-

ably the most sophisticated for calculating emissions from aviation is the Atmosfair calculator, as it takes into account breaks in journeys (layovers), fuel efficiency of different aircrafts, and occupancy levels and includes the IPCC radiative forcing multiplier for the release of greenhouse gas emissions at high altitude. However, although these calculators have the functionality to be reasonably accurate they require users to have a year worth of data or in the case of Landcare Research a month's energy data in the correct format before it is entered into the calculator. None of these calculators had the ability to save and store the carbon profile of the user until next time. The only calculators that had this functionality were Global Action Plan (GAP), RSA- CarbonDAQ and Landcare Research. For GAP the user can see a history of past entries, for RSA-CarbonDAQ the user can see their last profile and for Landcare Research the user can see the settings from his or her last entry making it quick to process an updated profile.

Carbon Effectiveness of Calculators

The second part of the review focuses on examining existing carbon calculators for their effectiveness in informing the public on personal carbon emissions. An effective carbon calculator is a tool that gives the user the ability to accurately measure and monitor carbon emissions over time; to understand what influences them; to be supported in taking carbon saving actions, to be connected to a community with shared interests as well as to easily access additional information and products related to energy and carbon.

In order to assess the effectiveness of the calculators reviewed, each tool was examined and scored using four key criteria. The four criteria areas were selected because a tool achieving success in each is likely to be meeting the aims of being accurate, informative, social and supportive. The four criteria areas were: 1) presentation and usability, 2) data and information inputs, 3) results, feedback and guidance and 4) context and explanation. A scoring system was devised to evaluate the strengths and weaknesses of each calculator in these four criteria areas (refer to table 4). Each calculator was awarded between 1 to 5 points in each of the criteria area, with 1 indicating the calculator was very weak in this area and 5 indicating the calculator to be very strong in this area. Each calculator was therefore allocated a maximum of 20 points. The scoring system made it possible to more fairly compare and contrast the calculators. The four criteria areas and the corresponding scoring system was developed by the author who has experience of creating Internet-based environmental tools as well as drawing on the research expertise on personal energy behaviour and information feedback at the Environmental Change Institute (e.g. Darby, 2006).

An effective Internet tool for personal carbon auditing must have high-quality presentation of information and good usability (see table 4). The user needs to understand what the tool does and what is involved to get the most out of the online experience. The overall design and architecture of the site as well as, the wording, graphics and visuals can greatly influence the experience of users and the value they attach to the tool being a beneficial resource to them. The usability of an Internet tool is a key component of its effectiveness; users must be able to easily navigate within and manipulate a calculator to meet their desired aims. Usability can also be about the accessibility of a site in terms of being fully operational in different web browsers and to users with special needs (e.g. sight impaired and colour blind). These latter usability issues are important, but were not considered in this review. Presentation and usability are two core aspects in the development of a tool, but it should be noted that the design of the Internet tool remains a subjective criterion.

As discussed earlier, the carbon accuracy of calculators is linked with the extent a user can input actual energy data and specify whether the calculator is calculating a carbon emission profile for an individual or a household. The calculators were scored for their ability to enable users to input actual data about their home energy and transport use (see table 4). Oftentimes the calculators reviewed gave the user a number of different data input options.

The third criteria area assessed in each of the calculators was their effectiveness in providing meaningful results, feedback and guidance to users (see table 4). Developing a carbon tool that will give users informative and motivational feedback on personal and household carbon emissions is probably one of the greatest benefits a tool that is aiming to be a stepping stone for carbon responsible behaviour can offer. The calculators were scored on the extent of feedback on the user's carbon impact; the opportunities for continued engagement; and links to further resources, services and products.

The final criteria area the calculators were evaluated was for "context and methodology", which refers to their ability to connect personal carbon to broader climate change and energy issues as well as the provision of information on how personal carbon emissions were calculated (see table 4). The context used and methodology given can be crucial elements in developing a carbon tool that successfully engages users in understanding why personal carbon responsibility is necessary. The context used by a carbon calculator does not necessarily have to explicitly link to global climate change, but does have to take into account that users have different motivations for reducing their carbon emissions. For example, motivational drivers for users to want to investigate their carbon emissions might be to improve comfort at home, to appeal to a particular self-image, to save money on energy use and/or to compete with peers. Calculators should draw upon these different levers to engage with users.

RESULTS OF CALCULATORS FOR CARBON EFFECTIVENESS

From the overall carbon effectiveness scores of the carbon calculators reviewed it is argued that these tools are falling short of providing users with an accurate, meaningful and social carbon tool by which they can have continuous learning and investigation of their carbon impacts (figure 1). The mean carbon effectiveness score was 10.5 ± 1.93, with the highest score going to Atmosfair (score - 16) and the lowest score going to COIN, MSN-Estimator, and Climate Friendly (score - 8). In table 5, the UK carbon calculators are grouped together and ranked from lowest to highest scorers for overall carbon effectiveness and non-UK carbon calculators are also ranked in this way.

Table 4: Explanation of the scoring system broken down by each criteria area

Score	Criteria Area
Presentation and usability	
1	calculations are not automated, user does themselves offline
2	all on one page, basic design; no images or graphics; all information presented numerically and text-based
3	attempts made to take user through calculation process in manageable steps; navigation not always clear; limited images and graphics used, but remains a pre-dominantly a numeric and text-based tool
4	clear navigation signals all through the calculation process; relatively uncluttered design; clear and concise text – room for improving definitions of all terminology used; a number of graphics and visual imagery used – but users have no flexibility in setting preferences for how they want the information conveyed.
5	clear navigation signals all the way through the calculation process; uncluttered design; clear and concise text with definitions of all terminology; a variety of graphics and visual imagery from which users can choose to have their carbon results conveyed
Data and information input	
1	user offered only default values
2	data inputs primarily focused on building fabric and technology
3	data inputs are energy expenditure per month, quarter or year
4	data inputs are quantities of energy used per month, quarter or year
5	data inputs can be raw energy data – e.g. actual energy meter readings
Results, feedback and guidance	
1	only a single figure carbon result given, no further breakdown or additional information
2	each activity separated and thus so it the carbon result, therefore the user cannot get a total carbon result; and limited additional information about personal carbon emissions is made accessible
3	users given a total carbon result and a breakdown by activity; results are presented graphically; some effort to put users' carbon result in context (i.e. in comparison to the national average); and links to further resources.
4	users can create a profile to add and monitor energy use and carbon emissions; the tool is not linked with social networking tools; more effort to put users' carbon results in context with other users; tool provides only generic guidance on what users can do to alter their carbon emissions.
5	user can build up a profile to add and monitor energy use and carbon emissions; results presented in clear metrics; relevant feedback is given to the user on his or her carbon results; the user's carbon profile is put in context to other profiles and emission reduction targets; the calculator is not a standalone resource it is embedded with social networking tools (i.e. carbon clubs which users can set up or join and discussion forums); the are multiple opportunities for interaction with users' own data and for sharing data; and accessible from the tool is a wide variety of other relevant resources.
Context and explanation	
1	minimal information is provided on the context of why a user should bother with the effort of calculating their carbon emissions; and there is no explanation of the methodology and assumptions used to calculate personal carbon emissions.
2	some context is provided, but there is no explanation of the methodology and assumptions underpinning the calculation of personal carbon emissions.
3	the carbon tool has made efforts to link personal carbon emissions and responsibility with the issue of global climate change, but the approach is too grandiose and abstract to fully resonate with users; the tool fails to inspire and motivate users to think their efforts can make a difference in solving the global problem of climate change; and there is some explanation of the methodology and assumptions used to calculate personal carbon emissions, but it is incomplete.
4	The carbon tool is linking personal carbon emissions and responsibility with climate change; the tool attempts to make this links not tool abstract, but there is still room for improving the language used (e.g. the tool still might use fear tactics for trying to motivate responsibility, which we know have limited ability in effectively engaging people). Reasonably clear explanations are provided on the methodology and assumptions used to calculate personal carbon emissions.
5	The tool uses a context that is inspiring and motivating to users to remain engaged in investigating and reducing their carbon impact – the context is not necessarily global climate change, but one that resonates with users; and the tool provides clear explanations of how personal carbon emissions are calculated.

Presentation and usability

Twenty of twenty-three carbon calculators were given a score of 3 or less for their presentation and usability. Calculators receiving this score did so because they had a functional design similar to a spreadsheet with hardly any images or graphics to communicate information. There were limited information pointers for individuals needing clarification of a term or of what information to input. The COIN calculator and one developed by someone in the Physics Department at the University of Sidney (Australia) were given a 1 for presentation and usability because they were passive tools requiring the user to do all the calculations themselves offline. Twelve calculators were only awarded a score of 2 because although they were designed to automatically calculate carbon emissions they had a formulaic design. In addition, several of the calculators compartmentalised personal carbon activities and did not join the information up. This was typically the case for the calculators of carbon offset companies that want to make it simple and quick for users to calculate and then offset their carbon emissions from a particular activity.

The carbon calculators that received high scores were BP, Climate Care, Eco-Speed and Atmosfair. BP scored well as they have developed a very visual calculator tool with careful balance of text and graphics. The architecture of the tool is well-

Table 5: Scores for carbon effectiveness of calculators reviewed

Organisation	Calculator Type	Presentation & Usability	Data & Info Inputs	Results, Feedback, Guidance	Context & Methodology	Total score
UK carbon calculators						
COIN	D	1	4	1	2	8
MSN - Carbon Estimator	D	2	2	2	2	8
South Hampton Sustainability Forum	D	2	3	2	2	9
CO2 balance	D	2	3.5	2	2	9.5
National Energy Foundation	D	2	4	2	2	10
World Land Trust Carbon Balance	D	2	4	2	2	10
Carbon Neutral	D	3	3.5	2	2	10.5
Bestfoot Forward - Stepwise	D+	3	4	3	1	11
BP	D	4	2.5	3	2	11.5
RSA - CarbonDAQ	C	3	3.5	3	2	11.5
GAP	D	3	4	3	2	12
Resurgence	D	3	4	3	2	12
Climate Care	C	4	3.5	2	4	13.5
Non-UK carbon calculators						
Climate Friendly	C	2	2	2	2	8
University of Sidney Physics Dept.	D+	1	3.5	2	2	8.5
Climate Crisis	C	2	3	2	3	10
Native Energy	D	2	4	2	2	10
The Climate Trust	C	2	3.5	2	3	10.5
Landcare Research	D+	3	3.5	3	1	10.5
Eco-Speed	D+	4	2	3	2	11
WRI - Safe Climate	C	2	4	3	2	11
Environmental Defense	C	2	5	2	3	12
Atmosfair	A	4	5	3	4	16

Key for calculator type: A = aviation only, B = home energy only, C = home energy, private vehicle use and aviation, D = home energy, private vehicle use, aviation, and public transportation, D+ indicates these calculators might also have covered additional areas such as water, waste, and food.

designed by asking the user to answer a series of questions in manageable sections, and receives constant feedback as he or she progresses through to the final carbon results page. The BP calculator of the calculators reviewed gave the highest level of attention to definitions with 'I' buttons for users needing further explanation. Similarly to the BP calculator, the Eco-speed calculator had a clear step-by-step process indicating to users how far they were through the calculator as well as a graph of energy usage and carbon emissions on the left-side of the webpage that altered as more information was entered. The Climate Care had a clean and logical design tool making it easy for the user to navigate through the steps. As with the BP calculator there were many 'I' (nformation) points for users wanting further clarification. The Atmosfair tool scored well because it was simple for the user to input flight details, interpret their carbon results, which were numerically and graphically presented as well as clear navigation links to further information on emissions from aviation.

The language used by a calculator is crucial for successfully encouraging, motivating, and inspiring people to investigate their carbon emissions and in making them feel personal actions can make a difference towards the transition to a low carbon energy society. In most cases the language used by calculators was from a pragmatic environmental perspective. None of the calculators were very imaginative in the phraseology they used to appeal to different types of users especially the "non-greenies" (i.e. the less explicit environmental audiences).

Data and information input

The carbon accuracy of a calculator is defined by the quality of the energy data being inputted. There was a spread in the calculator scores for this criteria area. None of the calculators covering home energy, private vehicle use and public transport use were given a score of 5, as none gave users the ability to input raw energy data such as gas meter readings. There is one calculator but not included in the review that does give users the option of inputting meter reading data – this calculator has been developed to support a network of people trialling the policy idea of personal carbon allowances (http://my.carbonrationing.org.uk/). Atmosfair received a 5 because in terms of calculating aviation emissions this calculator is probably as exact as it is possible with current scientific understanding. Eight calculators received a score 4 because they allowed a user to input annual figures for home energy use and for private vehicle use and users are able to specify information about the vehicle as well as the distance driven in a year. In these calculators the

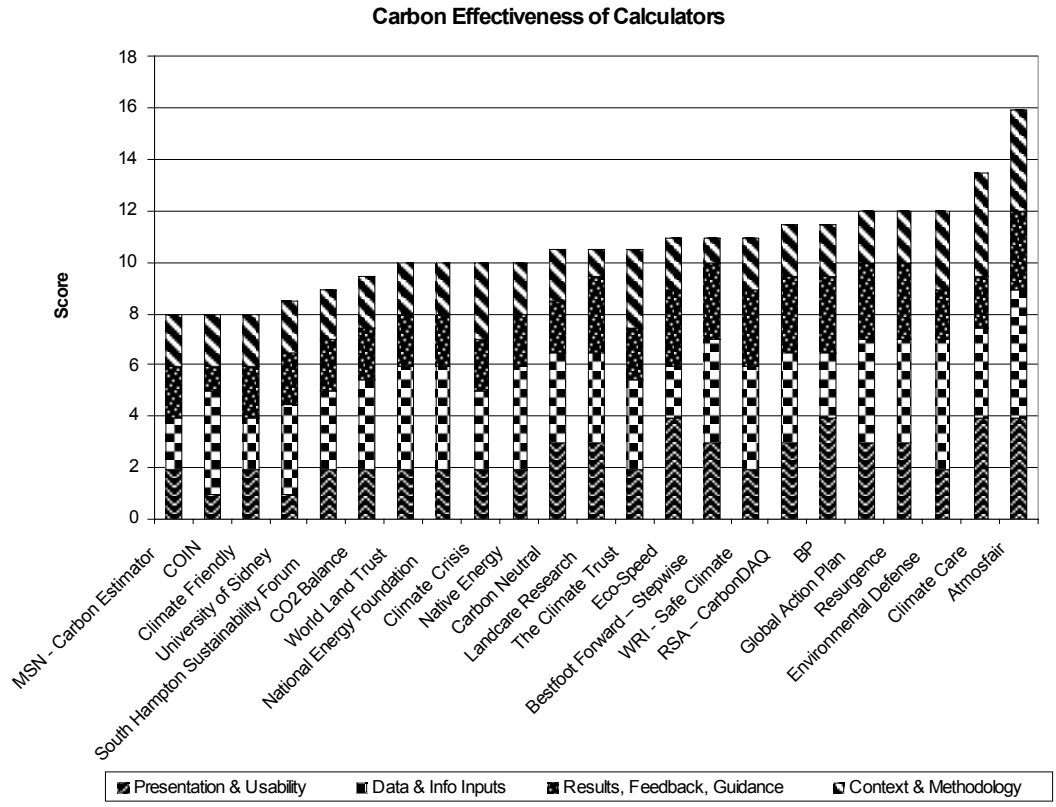

Figure 1. Carbon effectiveness of calculators

user wanting to enter in the number of energy units used will need to have interpreted their energy bills to some degree before being able to enter information into the tool. Because energy bills, especially those in the UK can be quite difficult to understand relying on this information source is a barrier to encouraging people to investigate their carbon emissions. However, this could change with new EU-wide regulations for informative customer billing and metering. The Landcare calculator was slightly different to the other calculators reviewed, in that it allows users to choose the month that their energy input data corresponds to. The idea behind this calculator is to motivate users to come back on a monthly basis to learn what their energy consumption has been and begin building up a carbon profile. The tool specification is still limited as the only way users can monitor their month to month consumption is by printing each month's carbon report.

Three calculators based carbon results only from energy expenditure information; these calculators received a score of 3 or 3.5 if they gave the option of entering in either energy expenditure or quantity of energy used (i.e. Climate Care). As explained earlier this is a poor proxy for determining the carbon emission profile of people. The Climate Crisis calculator promoted with the Al Gore movie "An Inconvenient Truth" is an example of a calculator only giving the user the option to indicate their expenditure for home energy use. The Climate Crisis calculator has a further limitation in that the users can not specify their actual expenditure, but a monthly range. The monthly range is then multiplied to give the annual energy expenditure which means the carbon result can only be approximation. The BP calculator may have performed well for presentation and usability, but scored low in the area of accurate data and information input because the carbon results are based solely on information about building fabric and technology. The user inputs no information on the quantities of energy they use. The BP tool is likely to be effective at introducing people to personal carbon issues, but this type of tool is ineffective at effectively supporting people in monitoring and reducing their actual carbon emissions.

Results, feedback, and guidance

Integral to the effectiveness of carbon calculators for encouraging learning, understanding and action on personal carbon emissions are the carbon results, feedback and guidance users receive through the process. Of the calculators reviewed many took a similar approach for providing users with their carbon results. The majority of calculators provide users with a total carbon emission result (e.g. Climate Crisis, BP, Resurgence). Many calculators will go a step further and give users a breakdown of their carbon emissions by activity. This breakdown is given numerically (e.g. Global Action Plan and South Hampton Sustainability Forum) and in some cases through a graphic representation such as a pie chart, bar chart or line graph (e.g. BP, WRI-SafeClimate, Environmental Defense, and RSA-CarbonDAQ). Many of the carbon calculators, especially those developed by carbon offset companies, tend to compartmentalise the different emission activities such as home energy, private vehicle travel and flights and do not provide a summary of carbon results (e.g. Carbon Neutral and Climate Trust). The SafeClimate calculator had the most imaginative approach for communicating to users their carbon results with a flash-based cartoon image with a rating scale going from angel to polluter.

In many cases the calculators reviewed provided limited feedback to users about their carbon results in context to other people's emissions. If a user gets a result of 6 t CO_2 from completing a calculator they are unlikely to be able to know if this value is high or low compared to the national average or to people with similar lifestyles unless this information is also given. A number of calculators do tell the user what the national average is for individual carbon emissions (e.g. WRI-SafeClimate, BP, Eco-Speed and Climate Crisis). A few calculators do try to put the carbon result of users in context by comparing their air emissions to other things; for example Atmosfair indicates that driving 12,000 km in a medium sized car is equivalent to 2 t CO_2 or that the annual per capita emission average in India is 900 kg CO_2 . None of the calculators indicated to the user how much the average per capita emission needs to be if, for example, the UK is to achieve a 60 per cent carbon reduction by 2050 (DTI, 2003). Also, many of the calculators were designed to be used by households and although they asked how many people lived in the house, this information is not necessarily reflected in the results and feedback. Of the calculators tested, only two gave both a household and person carbon result (.i.e. WRI-SafeClimate and Global Action Plan). Landcare provide the most in-depth feedback to users by creating a carbon monthly report which gives users information both numerically and graphically, in a report format. Landcare suggests to users to save their monthly report and to re-visit the site every month to get a new one. Almost none of the calculators give users the ability to build up a carbon profile and those that provide this functionality do so in a very limited way. The Global Action Plan calculator is one of the few calculators that require users to register. By having a registration process this enables the calculator to store users' carbon result and make them available for comparison the next time users input data into the calculator.

Only one out of the 23 calculators reviewed provides comparative information on how users' carbon results contrast to others, except for stating the national average. The RSA-CarbonDAQ is the only tool giving users carbon comparisons and this is with celebrity personalities that are participating in CarbonDAQ. None of the 23 calculators provide information on the spread of emission amongst users or the population more generally and therefore can not give users an indication of where they user falls within that spread.

The guidance provided to users once they get their carbon emissions is limited. Most calculators simply provide users with links to other web resources to gain a further understanding of personal carbon and energy issues. Most of the calculators gave generic tips to users to reduce their energy use and none gave personalised information to users on what measures they could first explore to reduce their carbon impact. All the carbon calculators were stand alone tools in that they did not connect to a virtual community of other people with interests in personal carbon responsibility. Therefore, social learning can not take place virtually as the opportunities for the sharing of knowledge and ideas are not presented to users.

Context and methodology

Understanding the context for why action is needed on personal carbon emissions and how those emissions are calculated are important parts of the process of developing carbon literacy and numeracy. Carbon calculators hope to raise awareness about climate change and to give people an insight into how their behaviour contributes to the problem by enabling them to calculate the carbon emissions they are directly responsible for. Many calculators did provide some background information about climate change and the carbon emissions coming from the combustion of fossil fuels, but this tended to be brief and was only presented in text with no pictorial explanations. A few calculators do not provide background information on climate change and energy issues such as Bestfoot Forward's Stepwise, South Hamption Sustainability Forum, and Eco-speed. Most calculators do not give any information on carbon emission stabilization and what that this will require. Furthermore, personal emissions are not put in context to the emission contribution of other sectors or national reduction targets.

To be effective communication and support tools carbon calculators should not overwhelm users with the full detailed explanations of the methodology used to calculate person carbon emissions. However, it can be helpful in providing some explanation of what the carbon numbers being communicated mean. Only six of twenty-three calculators reviewed did provide users with some explanation of the methodology behind the calculations and for the most part this was very limited. Atmosfair and Climate Care provide users with more detailed explanations of how personal carbon results were derived. Calculators such as National Energy Foundation, WRI-SafeClimate and COIN provided the data sources for the emission conversion factors. Other calculators did not make any information available about how carbon results were derived, such as Climate Crisis, BP and Landcare.

Overall

The carbon calculators reviewed were not atypical of the calculators currently available via the Internet. The functionality of these calculators is meeting the objective of introducing the concept of quantifying personal carbon emissions and in the case of offset companies giving people a sufficiently accurate estimate of their emissions so that they can purchase carbon offsets for those emissions. The usability and presentation of the tools in many cases reflect a limited attention to imaginative design and engaging language. The carbon accuracy of calculators is determined by what options are available for data to be inputted and users themselves. Many calculators did have the functionality for users to input actual quantities of energy used, but these calculators required users to have on the one hand a full year of data available and on the other hand to do some interpretation of the data before it can be inputted into the calculator, which is likely to be a significant barrier to successfully engaging people on personal carbon responsibility. Most of the calculators provide only simplistic information to users on their personal carbon impact, their interpretations and a limited guidance on the actions to be taken forward. A lot of the results and feedback were communicated as numbers and text with very little use of visuals and graphics. The only tools attempting to give users the on-going ability to monitor their carbon emissions were Global Action Plan and Landcare research, but in both cases the functionality for this was very basic. Generally the calculators assessed here were found to be designed only for a one-off use and therefore did not have the functionality for on-going engagement. In terms of context

and methodology, the linkages between the global challenge of climate change and personal contributions to the issue could have been clearer and more tangible. Without the appropriate context for measuring and acting on their carbon emissions individuals are likely to feel that efforts they take to reduce emissions will be insignificant and worthless.

The review of calculators was based on the subjective knowledge of the author. A next step to this research on Internet tool for behaviour change would be to test the validity of the results by asking a number of users to trial these carbon calculators and score them. In addition, there are a number of interactive lifestyle tools that do not quantify energy use and carbon emissions accurately, but do given users much more feedback on behaviour, building fabric and technology measures that if adopted might reduce energy use and carbon emissions. Examples of these tools are British Gas' Home Energy Survey (UK), Global Action Plan's Greenscore (UK), Energy Saving Trust's Save 20 % (UK) and Energy Box (Switzerland). Examining these tools in-depth would be helpful in the development of future carbon calculators.

The Next Generation of Carbon Calculators

The carbon calculators reviewed here all constitute a useful starting point to engage people on personal carbon issues. However, as mentioned above there is scope for greatly improving carbon calculators so that they are able to better support people through a process of learning, understanding, and taking action on personal carbon responsibility. The Internet gives users the ability to accurately quantify and monitor personal carbon emissions as well as access resources and connect with others to share data, information, ideas and experience. This section presents some ideas about how carbon calculators can develop into more effective interactive tools. The ideas presented are discussed using the same four criteria used to evaluate existing calculators (see table 4): presentation and usability; data input and information; results, feedback, and guidance; and context and methodology.

Presentation and usability

Calculators should have different levels of sophistication: from enabling people with approximations of their carbon emissions based on front of mind information to providing people with an in-depth tool by which they can accurately measure and monitor their personal or household carbon emissions. The interface and architecture of the calculator tool will be crucial to ensure that users can easily navigate through the tool in as little or as much depth as desired. The presentation and usability of a carbon tool will affect the experience users will gain from the tool; users are more likely to return to an Internet tool if they find it well-designed and can access the information they want within a couple of 'mouse' clicks.

Carbon calculator tools need to communicate information more visually and graphically rather than relying heavily on text and numeric presentations of information. Users are likely to absorb information more readily if it is presented in a coherent and visual way. Many people are not numerical and therefore presenting information this way is likely to disengage them from being interested in measuring and monitoring their carbon emissions. Calculators could be designed to have flexibility so that users can set default preferences such as having carbon results presented graphically, visually, numerically or a combination so information is presented as they want it.

A carbon tool providing on-going support to users requires a registration process. This enables users to create a secure carbon profile, from which they can regularly measure, monitor and investigate their personal carbon emissions.

Data input and information

In order for carbon calculators to give users accurate and effective carbon results and feedback they need to give users the ability to enter in actual energy data. As discussed earlier energy bills do provide energy consumption information, but as said these, especially in the UK, are estimated and tend to be difficult for people to decipher. Calculators can make the process easier for people by enabling them to input actual raw data, such as home energy meter readings and vehicle mileages. The calculators can then use the raw data to more accurately estimate the carbon emissions of a user. Calculators need to be designed to enable users to regularly input data, so over time users develop a much more accurate sense of their carbon emissions in contrast to the annual emission snapshot given by most of the existing calculators.

The development of technology and software for smart metering and appliance monitoring opens the possibility of automated data collection for households, which can in turn be linked directly with a carbon tool. This will reduce the level of effort required by users, thereby enabling them to develop a meaningful understanding of their personal carbon emissions without spending lots of time routing for the necessary data. There are already several devices available on the market for electricity (e.g. electrisave device).

The information inputted into calculators should incorporate behavioural aspects of energy use in addition to information about fuels, building fabric and technology. All this information becomes particularly important when a calculator interprets the users' carbon results and gives guidance on what options could be applied the most appropriately by the person to reduce carbon emissions.

Carbon results, feedback, and guidance

This area is the one in which Internet technology can really enhance the value of carbon calculators. To successfully engage people in issues of carbon responsibility, the carbon results need to be communicated to users in a way that is digestible and meaningful to them. Carbon results should be clearly broken down by activity – home energy, private transport, public transport and flights. People are likely to think there is more flexibility in altering their carbon emissions in certain activities over others, for example, changing light bulbs at home rather than modifying their driving patterns. Carbon tools need to take into account users' attitudes and perceptions when communicating carbon results. For example, flying can dwarf other carbon emitting activities and therefore make people feel that it is not worth making any efforts to reducing energy use in other areas of their life, as it will be insignificant in changing their carbon profile compared to the emissions generated from flying which in the short-term they may feel they can not change. Therefore, calculators need to get the balance between communicating to users their full carbon emission impact and still

motivating them to change their emissions where they can and want to.

Receiving a carbon impact figure from a calculator is unlikely to resonate with users unless it is in presented in the context of other carbon profile results. People are likely to want to be compared with those they see, as being similar to them. Calculators should be designed to enable users to benchmark themselves against other people they feel they have a similar lifestyle – for example, live in a detached house, high home occupancy, no children, travel by car and go on holiday each year in Europe. People should be able to choose the metric by which they want the information to be presented because although they are likely to choose the one that puts them in the most favourable light it is also likely to keep them involved and motivated to learn and potentially change their carbon emission impact.

Internet technology offers a unique ability to connect people in a time-unconstrained manner. None of the calculators reviewed take advantage of social networking tools for engaging people in personal carbon, but this is a direction the next generation of calculators should explore. The availability of social networking through carbon calculators could give all sorts of opportunity for data sharing, comparison, grouping, competition, and support. As many of the social networking tools such as My Space and Frienster are demonstrating certain people gravitate towards these interactive experiences and enjoy being able to identify, connect and network with likeminded people. These social networking tools are part of the Web 2.0 phenomenon, which is the movement away from passive Internet information flows to much more social interactive engagment (O'Reilly, 2005).

Incorporating social networking into carbon tools could be a way to engage a broader range of people in personal carbon responsibility. Internet social networking can also create links for virtual information exchange or be an additional resource for offline initiatives. For example, communities running carbon neutral programmes could use an Internet-based calculator to quantify and monitor the carbon emissions of participating households as well as provide a forum to exchange ideas and experience between households as they reduce emissions. These social networking tools are not simple to implement and require considerable effort of the hosting organisation to design the functionality users want and to nuture the virtural community (Preece, 2000).

Context and methodology

Personal calculator tools will benefit from the development of standards and guidelines for how to quantify personal carbon emissions. At the moment no standard methodology exists and as a result there are significant variations between calculators making it confusing to users on which one to trust. In addition, there are some issues which developers of calculators may find it helpful to provide guidance on, such as how to carbon count green electricity and bio-fuels as well as embodied carbon, as it becomes possible to systematically quantify these emissions.

Conclusion

Internet-based carbon calculators offer individuals the ability to quantity, understand and act on their personal carbon emissions, specifically those from home energy and travel. The review of twenty-three carbon calculators into their carbon accuracy and effectiveness concluded that all are falling short in providing users with a tool that is carbon accurate; enables on-going monitoring of carbon emissions; provides personalised feedback and relevant guidance; or one that uses social networking tools. Internet technology is developing into multimedia communication tool that is driven by the user. This development of Internet technology holds great potential for connecting people in innovative ways around personal carbon responsibility. The Environmental Change Institute is actively working on developing a next generation carbon calculator.

Acknowledgements

I would like to thank my colleagues Russell Layberry, Chris Jardine and Muriel Bonjean.

References

Bandura, A (1977). Social Learning Theory. Englewood Cliffs, NJ: Prentice-Hall.

Darby, S. (2006) The effectiveness of feedback on energy consumption: A review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute, Oxford

Dokken, D., Griggs, D., Lister, D., McFarland, M. and Penner, J. (1999) Aviation and the Global Atmosphere. Intergovernmental Panel on Climate Change - http://www.grida.no/climate/ipcc/aviation/

Jardine, C. (June 2005). Aviation Emissions and Offsets. Environmental Change Institute, Oxford University.

O'Reilly, T. (2005) 'What is web 2.0? Design Patterns and Business Models for the Next Generation of Software'

Preece, J. (2000) Online Communities: Designing Usability and Supporting Sociability. John Wiley & Sons, New York

DTI (2003) Our energy future – creating a low-carbon economy. Energy White Paper. Department of Trade & Industry, The Stationery Office, London, UK http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf

Web-addresses to all calculators reviewed

Organisaton	Web Addresses
UK Carbon Calculators	
Bestfoot Forward - Stepwise	www.bestfootforward.com/carbonacc.html
BP	www.bp.com/carbonfootprint
Carbon Neutral	http://www.carbonneutral.com//shop/index.asp
Climate Care	http://www.climatecare.org/index.cfm
CO2 balance	http://www.co2balance.com/home.php
COIN	http://coinet.org.uk/projects/challenge/measure
Global Action Plan	http://www.carboncalculator.com/
MSN - Carbon Estimator	http://specials.uk.msn.com/carbonemissionsestimator
National Energy Foundation	http://www.nef.org.uk/energyadvice/co2calculator.htm
Resurgence	http://www.resurgence.org/carboncalculator/index.htm
RSA – CarbonDAQ	http://www.rsacarbonlimited.org/emissions/default.aspa
South Hampton Sustainability Forum	http://www.southampton-sustainability.org/carboncalc.htm
World Land Trust - Carbon Balance	http://www.carbonbalanced.org/personal/calculators.htm
Non-UK Carbon Calculators	
Atmosfair	http://www.atmosfair.de
Climate Crisis	http://www.climatecrisis.net/
Climate Friendly	http://www.climatefriendly.com/
Eco-Speed	http://eco2.ecospeed.ch/privat/index.html?ln=1&us=1
Environmental Defense	http://www.fightglobalwarming.com/carboncalculator.cfm
Landcare Research	http://www.carbonzero.co.nz/calculators/calculators_home.asp
Native Energy	http://www.nativeenergy.com/individuals.html
The Climate Trust	http://www.carboncounter.org/
University of Sidney - Physics Dept.	http://www.physics.usyd.edu.au/~cdey/calculator.pdf
Other tools referred to in paper	
British Gas – Home Energy Survey	http://www.house.co.uk/energysaver
Carbon Rationing	http://my.carbonrationing.org.uk
Energy Box	http://www.energybox.ch
Energy Saving Trust – Save 20%	http://www.est.org.uk/myhome/20percent/
Global Action Plan – Green Score	http://www.greenscore.org.uk/