Green household index - The Eco-Cal

Background information

Going for Green Ltd

R&D Project Record E2/007/1

Further copies of this report are available from:

Foundation for Water Research, Allen House, The Listons,
Liston Rd, Marlow, Bucks SL7 1FD. Tel: 01628-891589, Fax: 01628-472711

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Background information

J Sutton

Research Contractor:
Going for Green Ltd

Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS12 4UD

R&D Project Record E2/007/1

Publishing Organisation
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS12 4UD

Tel: 01454 624400 Fax: 01454 624409

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This report consists of background information used to develop the Green Household Index. the main report R&D Technical Report E46 is aimed at all Environment Agency staff.

Research contractor
This document was produced under R&D Project E2-007 by:

Going for Green Ltd
Churchgate House
56 Oxford Street
Manchester
M60 7HJ

Tel: 0161-272 5221 Fax: 0161-272 5200

Environment Agency's Project Manager
The Environment Agency's Project Manager for R&D Project E2-007 was:
Peter Fox - Environment Agency North West Region

Green household index - The Eco-Cal

Executive Summary

In July 1996, Going for Green approached the Environment Agency with the idea of developing a tool for householders to measure their environmental impacts. In October 1996, the Environment Agency agreed to share the costs of research and development, allocating a sum of £50,000 to the project.

Two consultancy teams were commissioned to work on the project, CAG Consultants to develop the use of ecological footprinting and its application to household activities. UserData and Pulsar International (now Best Foot Forward) were commissioned to represent this work in a way that would be meaningful and attractive to the public.

Note that both the Eco-calorie assumptions (CAG Consultants) and market testing results (UserData and Pulsar International) are presented in this document as background information for the project, whilst the overall findings and the Eco-Cal model are presented separately in the R&D Technical Report E46.

Formulae were developed that would take each household activity, quantify its associated environmental impacts, then for each impact, calculate its ecological footprint.

Best Foot Forward began work in January 1997 on producing questions which would be straight forward to answer, yet supply the household details required by the algorithms to calculate the EcoCal score.

The first versions of EcoCal (computer) and EcoCal (paper) were available at the end of April 1997 and a month of market testing was arranged for both products during May 1997.

A summary of the results of testing include:

- more than 74% found the EcoCal on computer easy to use;
- 50% found the paper EcoCal easy, a further 35% found it neither easy nor difficult;
- 83% expressed satisfaction with EcoCal on computer;
- 73% were satisfied with EcoCal on paper;
- After using either product there was an increase in those "concerned" about the environment;

Following the feedback from market testing, around fifty changes to the products were commissioned. Key changes to the computer EcoCal were on improving the installation

procedure, providing a more detailed help page and re-designing the movement between question pages.

Because of the extensive revisions made to the computer version of EcoCal, this product underwent a wide period of acceptance testing before launch.

EcoCal was launched at the Regents College Conference Centre in London on Wednesday 22 October by Michael Meacher MP. Simultaneous launches were held at other venues across England and Wales.

Substantial national media coverage was obtained with broadcasts on the day on Radio 5 live, ITN Lunchtime News, the World Service, BBC Radio One, Channel 4 and Channel 5 Evening News and a prominent piece in the Daily Mirror the following day. The regional launches also generated a large amount of local publicity.

Members of the public were invited to phone 0345 00 21 00 for a free copy of EcoCal. In the first two days following launch, this number received nearly one thousand calls.

The development and launch of EcoCal has been a highly successful product of partnership between Going for Green and the Environment Agency. When launching EcoCal, Mr Meacher recognised this, saying: "The UK is once again leading the way in translating sustainable development into practical steps for people".

Going for Green wishes to record its thanks to the Environment Agency for supporting the research and development costs for EcoCal. Without the Agency's financial and other input into the project, this success would not have been achieved.

KEYWORDS

Eco-calorie EcoCal Assumptions Market-testing Impact Environment Energy Transport Water Waste Shopping

EcoCal Market Testing Results

CAG

CONSULTANTS

PROJECT REPORT FOR GOING FOR GREEN

ECO-CALORIE ASSUMPTIONS

April 1997

CAG Consultants
Antonia House
262 Holloway Road
London N7 6NE
Tel: 0171 607 7017
Fax: 0171 700 7840

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PART I

OVERVIEW

PART 1: OVERVIEW

1. INTRODUCTION

The aim of Going for Green's eco-calorie project is to develop a simple measure which gives ordinary people some indication of how green their lifestyles are and how they can reduce their impact on various aspects of the environment. Userdata and Pulsar have been commissioned to develop such a measure into a computer quiz and a manual questionnaire, and there are plans to field test the measure shortly with households participating in Going for Green's Sustainable Community projects.

In the initial stage of the project, CAG was asked to advise on the feasibility of developing a single measure of household environmental performance. The overall feasibility is the subject of a separate report to Going for Green. This report reviewed a number of alternative approaches and identified 'ecological footprinting' as a potentially attractive methodology for measuring some types of impact.

Following on from the feasibility report, CAG were asked to advise Going for Green on how such a measure of household environmental performance might be constructed. While Userdata/Pulsar are responsible for assessing and refining the marketability of the proposed measure, a Reference Group was appointed to assess the validity of our proposals from an environmental viewpoint. This group comprised Duncan McLaren (Friends of the Earth), Catherine Unsworth (New Economics Foundation), Peter Fox (Environment Agency), Trevor Dixon (University of Buckingham) and Michael Jacobs (LSE).

The first meeting of the Reference Group, in November 1996, reviewed the bare bones or proposed 'architecture' for a measure, or small group of measures, of household environmental impacts. While the Reference Group felt the proposed approach was highly ambitious, they felt that - if appropriate data could be found to 'flesh out' the architecture - it could provide useful signals to influence people's behaviour.

The second meeting of the Reference Group, in February 1997, reviewed the structure and data largely as set out here. Some improvements were suggested which we have since investigated in more detail and, where appropriate, incorporated.

2. SUMMARY OF METHODOLOGY

The overall structure of the measure we propose is shown in the diagram below. We divide household activities into a number of activity groups, each of which contributes to a range of environmental impacts. We only include impacts which are likely to affect environmental impact significantly and have had to make assumptions on realistic 'cut-off' points for the infinite regress of life-cycle analysis which is implicit in these impacts.

In our original design for the measure, impacts were grouped into three main categories: ecological impacts, health impacts and impacts on the quality of the local environment. For each group of impacts, we proposed a way of combining these impacts into a measure of damage: 'land footprint' for ecological impacts; 'health points' for health impacts and a measure called 'frowns/smiles' for local environmental quality. The objective evidence for linking impact to damage was in many cases tenuous and in some cases non-existent, so we used our imaginations to find plausible ways of deriving some assessment of the damage sustained as a result of these impacts.

The lack of information on health and local environmental quality led us to conclude, with Userdata/Pulsar and Going for Green, that the measure should only quantify ecological impacts at this stage. The assumptions used to estimate the land 'footprint' of different types of ecological impact are set out in Chapter 3, while the assumptions used to estimate the different ecological impacts of each group of household activities is set out in Chapters 4-10. The ultimate 'footprint' of a particular household activity is calculated by combining the 'activity to impact' and 'impact to footprint' calculations, as illustrated in the spreadsheet in Appendix A.

For future reference, this volume also includes some documentation on the incomplete, and unused, methodologies for converting health and local environmental quality impacts (see Appendix C). Chapter 3 discusses the difficulties which would have been encountered in combining the three measures of ecological footprint, health and local environmental quality into a single 'eco-calorie'.

Given the decision to use a simple, ecologically-based measure at this stage, the term 'eco-calorie' in this report refers to the footprint measure which combines the different ecological impacts set out in the diagram below.

Diagram showing structure of measure

Activity groups

- Transport
- Energy
- Water use
- Shopping
- House & Garden
- Waste
- Voluntary Actions

Range of impacts considered

- Global warming potential
- Acidification
- Eutrophication
- Summer smog
- Water resource depletion
- Land for biomass
- Bio-diversity reserve
- Degraded/built-up land

Measure of damage

- Footprint (ecology)

Caveats

We need to preface the footprint calculations with some pretty strong 'health warnings'. Apart from energy, the only topic where the 'footprinting' approach has actually been followed through systematically by previous researchers, there is no body of generally accepted and settled methodology for footprinting. Lots of people are talking about the *idea* of footprinting; few have actually tried to calculate footprints; and then only for a very restricted range of impacts.

We have had immense trouble finding 'pathways' from impacts to footprints which are scientifically at all defensible and for which remotely relevant data is available. We have therefore had to make creative and frequently heroic assumptions about how impacts can best be translated into footprints, and then how the available data can be interpreted in 'footprint' terms.

The notes in the following chapters present the routes and assumptions chosen and the data and calculations made. The coefficients we reach are in **bold type**. This report is only a summary of our proposed answers, which draw on extensive background material documenting why other (often more intuitively plausible) approaches proved impossible and had to be discarded.

We have to emphasise that different routes or assumptions or better data could alter several of the coefficients by orders of magnitude, not just by a few percentage points. For example we have been repeatedly warned by the scientists we have consulted that for many impacts there are important 'threshold' effects which make any attempt at aggregation foolhardy. To take one example, at low concentrations sulphur dioxide acts as a fertiliser, *increasing* bioproductivity! The concentration beyond which this effect changes to damage, and how much loss of bioproductivity can be ascribed to each unit of acid deposition, varies enormously with soil and vegetation type, altitude, rainfall and so on. In cases like this we have had either to make guesstimates of middle or typical cases, or work back from aggregate data which necessarily hides a great deal of variation.

As our first stage report forewarned, we have also had to make fairly sweeping assumptions to convert (for example) aquatic and biodiversity impacts into footprints.

We are confident we have done as good a job on all this as is possible without a far larger and longer research project to go deeply into the raw (and often unpublished) scientific data and construct new causal models to tie impacts to effects. The assumptions presented here as put forward as our current 'best estimates', with the understanding that they can and should be revised and improved as better information becomes available.

On the plus side we feel this exercise has tended to confirm that footprinting is the best - indeed the only credible - way of reducing different ecological impacts to a common measure, and that the basic architecture we have put forward - the two step conversion from activities to impacts to footprints - is the right one and can accommodate any degree of future improvement in data and understanding. Only the coefficients (and possibly the categorisations of impacts) will need to be changed.

PART 2

ASSUMPTIONS

PART 2: ASSUMPTIONS

3. TRANSLATING IMPACTS INTO ENVIRONMENTAL DAMAGE

3.1 Introduction

Impacts on the ecological system are translated to a common measure of ecological damage called the 'ecological footprint'. The methodology below builds on previous work using the footprint approach, particularly the work undertaken in Canada by Rees and Wackernagel.

Impacts relating to health and the quality of the local environment cannot be translated into land equivalents or 'fooprints' in the same way. As documented in Appendix C, attempts were made to find a common measure for environmental damage in each of these two categories. Unfortunately, no measures could be found which adequately combined useability with theoretical rigour. The model does not therefore quantify damage to health and local environmental quality within the eco-calorie measure, but provides hints and tips on these aspects of the environment when appropriate.

The quantification of health impacts within the eco-calorie measure may become feasible in future when links between health and the environment have been researched in more detail. Damage to health could, for instance, be translated into a common measure of expected life-years or quality adjusted life-years.

Even if satisfactory measures could be derived for damage to health and, separately, for damage to the quality of the local environment, there is unlikely to be any sound theoretical basis for translating these three aspects of the environment into a single measure. As discussed at the end of Appendix B, the relative weighting of ecological, health and local environmental quality measures would still require subjective judgement (eg. derived from a 'Delphic' expert panel or from public consultation).

3.2 Footprints

The eco-calorie model currently quantifies eight different types of ecological impact. This chapter describes how each of the following impacts is translated into an ecological footprint:

- global warming
- acidification
- summer smog
- water resource depletion
- degraded or built-up land
- bio-diversity reserve or biomass land
- eutrophication

While the methodologies for global warming, degraded or built-up land, biomass land and bio-diversity land are fairly well established in the literature, we have gone further in developing footprinting methodologies for acidification, summer smog, water resource depletion and eutrophication. For each type of impact, there are a number of ways in which an estimated footprint could be derived. We present the reasons for our choice of methodology, but accept that there may be equally plausible alternatives in each case. While we believe that these methodologies represent our current 'best guess', we fully expect these assumptions to be refined and revised over time as understanding of the environment develops and improves.

(a) Global warming

Source: *Our Ecological Footprint,* M. Wackernagel & W. Rees, New Society Publishers, 1996
The footprint of energy use varies depending on the method of energy generation - the more renewable energy, the lower the footprint. Footprints for fossil fuels have been calculated by Wackernagel and Rees in 3 ways, ie. the estimated area that would be required to grow fuel crops (ethanol) sufficient to replace the depletion of fossil energy; the land area necessary to support forests sufficient to absorb the CO_2 produced by the burning of fossil fuels; the land area required to grow the biomass (trees) to replace the energy which was consumed. Hydro-electricity, solar and wind energy are essentially calculated on the basis of the land needed to run the power generation process (including land occupied by dams). Wackernagel and Rees do not make estimates for nuclear energy or other renewable energy sources. Their estimates for energy footprints are shown below.

Energy Source	Productivity (in gigajoules per hectare per year)	Footprint for 100 gigajoules per year (in hectares)
Fossil fuel		
ethanol approach	80	1.25
CO_2 absorption approach	100	1.0
biomass replacement approach	80	1.25
Hydro-electricity	1000	0.1
Solar hot-water	up to 40,000	0.0025
Pholtovoltaics	1,000	0.1
Wind energy	12.500	0.008

Source: M. Wackernagel & W. Rees, *Our Ecological Footprint,* New Society Publishers, 1996

In the UK nuclear power stations account for 21% of electricity supplied, hydroelectric 2%, and other renewables less than 0.3%. Given the very low rate of use of renewable energy in the UK and the absence of footprint figures for nuclear power, it is proposed to use the average energy footprint for fossil fuels, ie. **1.1667 hectares per 100 gigajoules per year.**

Alternatively, for impacts measured in CO_2 equivalents, Wackernagel and Rees estimate that average forests can accumulate approximately 1.8 tonnes of carbon per hectare per year. (1 ton of carbon is equivalent to 44/12 tonnes of CO_2.) **Therefore the footprint for CO_2 equivalents is** (1.8 x 44/12 =) **6.6 tonnes of carbon dioxide per hectare - or 0.152 hectares per tonne of carbon dioxide.**

(b) Acidification

Sources:
- *Valuation of Environmental Externalities*, Department of Transport 1995

- *Climate Change, Acidification and Ozone - Potential Impacts on the English Countryside,* Countryside Commission, 1995
- personal communication, Jane Hall, Institute of Terrestrial Ecology
- *Effects of Air Pollution on the Environment*, Proceedings of a Symposium, Cumbria 1994, DoE Air Quality Division.
- *ExternE*, Vols 1-4, European Commission
- *Critical Loads : Concepts and Applications*, ed. M. Hornung & R. A. Skeffington, Institute of Terrestrial Ecology, 1993.
- *The Eco-indicator 95*, Netherlands Agency for Energy and the Environment

The emission of pollutants have a potential impact as follows:

1. Emissions (eg. tonnes of SO_2) $\rightarrow$
2. Dispersion over the affected area $\rightarrow$
3. Ambient concentrations in air, soil or water (eg. pH of rain or ppb of SO_2 in air) $\rightarrow$
4. Impact on critical loads / thresholds $\rightarrow$
5. Impact on ecosystems $\rightarrow$
6. Impact on biodiversity and land productivity / yields over the affected area (eg. x% decline in yields over y hectares)

To calculate a genuine footprint it would be necessary to be able to make a direct link between stage 1 and 6. In fact, for the following reasons, this is currently not possible.

i) There are no simple ratios linking emissions to ambient concentrations and area affected (stages 1 to 3). Concentrations depend on topology, weather conditions and distance from source. There has been some modelling of a very small number of power stations by ExternE, an EU project, but there are no easy conversion ratios.

ii) The impact of ambient concentrations depends on whether they are below or exceed critical loads or thresholds. If concentrations are well below critical loads (for SO_2 this is 30 $\mu g\ m^3$ for a 10% decline in wheat yields) then additional emissions will not affect productivity. Indeed, research has suggested that SO_2 and NO_2 can have a positive nutritional effect at low levels, and can also reduce pests.

iii) The critical load depends on the receiving ecosystem. For example, some soils are much more sensitive to acid depositions than others. Critical load maps for soil acidity have been prepared for 1km squares for the whole of the UK. These express the acid load which would increase natural acidification by 0.2pH. The critical loads range from 0.2 to 4.0 keq H^+ ha year for different soils. Therefore, the impact of any emissions will also depend on where they are ultimately deposited.

iv) The impact of ambient concentrations on yields depends on the type of crop being considered, some are more sensitive to pollution than others. The form that the pollution takes is also a factor. SO_2 in the air does appear to affect crop yields, but once converted through deposition into soil acidity, this can be (and is) easily compensated by the application of lime. The steady increase in crop yields has also far outweighed the impact of air pollutants on yields. The most important consequence of acidification is therefore the damage to tree foliage and to natural grasslands, for which the concept of yields is not appropriate. Finally impact on yields are usually expressed as threshold impacts, eg. ambient concentrations which will reduce yields by 10%. There are no estimates for how much an extra x% of ambient concentrations will additionally effect yields. Also such ratios, if available, would almost certainly not be constant, and are likely to increase as concentrations become higher.

Current science is therefore not a stage where it is possible to calculate a genuine footprint for acidification. As an alternative we suggest that total UK emissions of SO_2 and NO_2 are equated to the land area in the UK which currently exceeds critical loads of acidity.

Percent of UK land area which exceeded critical loads for acidification in 1992 = 32%
UK land area = 24,500,000 hectares
Therefore land area which exceeded critical loads for acidification = 7,840,000 hectares

Total UK emissions of SO_2 in 1992 = 3,496,000 tonnes
Total UK emissions of NO_2 in 1992 = 2,513,000 tonnes
Eco-indicator weighting of relative impact on acidification SO_2= 1, NO_2= 0.7
(Source: *The Eco-indicator 95*)

Therefore total emissions of SO_2 equivalents in 1992 = 3,496,000 + (2,513,000 x 0.7)
= 5,255,100 tonnes

Therefore 1 tonne of SO_2 equivalent is on average responsible for 1.49 hectares of UK land exceeding critical loads for acidification.

However, there remains the unanswered question - how much land would be needed to compensate for each hectare which exceeds critical loads? Clearly, the extent of damage will in practice depend on the extent to which the critical load is exceeded. However, a conservative approach would be to assume that the loss in biomass yield in areas exceeding critical load would generally be equal to, or greater than, the 10% decline in wheat yields observed at the critical load of SO_2 of 30 $\mu g/m^3$. If areas exceeding critical load for acidification yielded on average 10% less biomass than 'normal' areas, then **1 tonne of SO_2 equivalent would have a footprint of at least 0.15 hectares.**

(c) Summer smog

Sources:
Climate Change, Acidification and Ozone - Potential Impacts on the English Countryside, Countryside Commission, 1995
Effects of Air Pollution on the Environment, Proceedings of a Symposium, Cumbria 1994, DoE Air Quality Division.

Calculating a footprint value for summer smog, ie. tropospheric ozone, encounters all of the same problems as for acidification described above. However, the chemical compounds which contribute to the formation of tropospheric ozone and their sources are so varied, that as yet there have been no estimates of UK emissions. The WHO guidelines for maximum ozone concentrations for vegetation are an average maximum 30 ppb during the growing season. (Source: *Climate Change, Acidification and Ozone - Potential Impacts on the English Countryside*). A UNECE Working Group has established a critical level for ozone as cumulative exposure above 40ppb of 5300 ppb.h (May-June) for a 10% loss in wheat yield. (Source: *Effects of Air Pollution on the Environment.*) Unlike acidification, there is no easy method by which farmers can compensate for the impact of tropospheric ozone, and therefore its impact on land could be seen as more severe. However, these critical load figures do not help in the calculation of footprints, because currently no ratio exists which links tonnes of emissions of the contributory chemicals (PCOP, VOC and NO_x) to O_3 concentrations per hectare.

Faced with this lack of information, we suggest that the only way of estimating an 'order of magnitude' footprint for ozone is to draw analogies with the acidification footprint. The level of maximum recommended concentration of ozone (30 ppb) is roughly equivalent to the maximum recommended concentration of SO_2 equivalent gases for acidification. Assuming - highly speculatively - that this equivalence of critical levels suggests an equivalence in extent of damage, we might expect the footprint of a tonne of ozone to be of the same order of magnitude as the footprint of a tonne of SO_2 equivalent.

However, we still need to relate the footprint of a tonne of ozone to the footprint of the contributory chemicals (PCOP, VOC and NO_x). The conversion of troposhperical pollutants to ozone is dependent on a complex set of factors, including the concentration of different pollutants and the action of sunlight. It would seem unreasonable to assume that each molecule of PCOP equivalent leads to the generation of one molecule of ozone. But given that tropospherical ozone is mainly a problem during the summer months, which coincide with the period of vegetation growth when the risk of damage is greatest, we suggest - on a wholly speculative basis - that **one tonne of ozone-contributing pollutant PCOP(or VOC, NO_x translated to PCOP equivalents) is assumed to have about half the footprint of acidification-pollutants: ie. 0.075 hectares per tonne.** (The Eco-Indicator 95 report estimates that the impact of 1 tonne of PCOP is equivalent to 0.398 tonnes of VOC; we assume an equivalent weighting for NOx.)

(d) Water resource depletion

Source: Tim Heff, Silsoe College

Three alternative methods of deriving a footprint for water resource depletion were considered:

i) rainfall catchment area

ii) reservoir area

ii) diversion from agriculture

Rainfall catchment area: for a given quantity of water used, we could calculate the land area required to catch an equivalent amount of water in a typical year's rainfall (assuming average rainfall for the region). This approach can be taken to imply that the amount of water received through average rainfall is consistent with the 'natural' ecological system in that region, and that any diversion of water into the public water supply potentially affects biodiversity. A serious problem with this method is that land receiving rainfall has many other potential uses: the water footprint of the UK calculated by this method would represent a large proportion of the country's land area, and would cover land which is also used to grow crops, feed livestock and so on. We have not used this method because of the double-counting involved.

Reservoir area: One way to reduce double counting would be to measure the area of single-purpose reservoirs and water catchment facilities which are dedicated to the water supply. This would implicitly assume that these areas were 'taken out of action' for biomass production. We have not used this method because we are elsewhere treating inland water bodies as having (aquatic) bio-diversity potential - again there would be an element of double-counting.

Diversion from agriculture: Our preferred method of deriving a footprint for water use is to calculate the reduction in land productivity caused by diverting water use away from agriculture. Householders' and industries' use of water is most likely to compete with water used to irrigate crops. (Strictly speaking, household water consumption borrows from the water resource rather than absolutely reducing the water available. In practice the water is lost to irrigation if, as in most cases, sewage effluent eventually flows into the sea.) Irrigation is mainly used for vegetables, of which the most representative in the UK is potatoes.

All crops have a theoretical water efficiency, that is the volume of water required to produce one tonne of the crop. Silsoe College have provided estimates for the water efficiency of potatoes as follows:

0.09 to 0.15 tonnes of potatoes per mm hectare of water
(Source: P Bailey, *Irrigated Crops and their Management.* Farming Press, 1990)

The average water efficiency for potatoes is therefore:

0.12 tonnes of potatoes per mm hectare of water
(1hectare = 10,000 sq metres, so 1mm hectare of water = 10,000 ÷ 1000 = 10 cu metres)

or

0.12 tonnes of potatoes per 10 cu metres = 0.012 tonnes of potatoes per cu metre

Average irrigated yields of potatoes is 40 tonnes per hectare.
Therefore to compensate for loss of 0.012 tonnes of potatoes, we would need:
0.012 / 40 hectares of land = 0.0003 hectares of land

By this method, 1 cu metre of water (1000 litres) has a footprint of 0.0003 hectares of land.

(e) Degraded or 'built-up' land

It is proposed to count the area of land which is degraded as having one to one equivalence with footprint area. This assumes that degraded land is defined to be built-up land with no ecological value. It should be noted that we are not assuming that a hectare of 'contaminated' land would necessarily count as one hectare of 'degraded' land, since contaminated land may have some form of productive use or, in some cases, may develop high bio-diversity value as untended 'wasteland'.

(f) Biomass land and Bio-diversity reserve

Land used to grow biomass for consumption (eg. food or wood products) is included in the footprint on an area for area basis.

As explained by Wackernagel and Rees in their book 'Our Ecological Footprint', the footprinting methodology cannot readily deal with bio-diversity effects. They propose that bio-diversity is dealt with by notionally reserving a proportion of the earth's surface as a 'bio-diversity' reserve which is not used for other productive purposes. We adopt this approach and count any change in the area of land which acts as a bio-diversity reserve as having a one to one equivalence with footprint area. As we are focusing on changes in the bio-diversity reserve, we can leave aside the question of how big a bio-diversity reserve should be maintained within or outside the UK.

(g) Eutrophication

Source: *The Eco-indicator 95*, Netherlands Agency for Energy and the Environment
Fact Sheet, Soap and Detergent Industry Association
The UK Environment, HMSO 1992.
Digest of Environmental Statistics (No.18,1996)

Eutrophication is caused by excess nutrients in lakes, rivers or other water bodies, causing excessive growth of algae. While nitrogen and carbon contribute to eutrophication, phosphorus (as phosphate) is generally regarded as being the limiting factor on algae growth in most cases in the UK. The critical load for phosphates is 0.15mg/l (Source: *The Eco-indicator 95*) but levels several times higher than this are observed in some parts of the UK.

One approach to assessing the impact of phosphates would be to look directly at the volume of water affected, rather than trying to find a link between ambient levels in air or water and their impact on land. This would suggest that 0.15mg of phosphate damages 1 litre of water. However, it is then problematic to convert a volume of water into a land 'footprint'. The only possible method would be to use the water resource ratio described above, assuming that eutrophied water was not suitable for irrigating potatoes. The problem with this approach is that phosphates are fertilisers, so there would arguably be a higher, rather than lower, biomass yield from land irrigated with eutrophied water.

Closer analysis of the problem of eutrophication suggests that bio-diversity in freshwater habitats is the real issue, not biomass yield from land. We therefore propose to develop an approach which treats a freshwater lake or river of given surface area as equivalent to the same surface area of bio-diversity reserve. Since this approach deals with water quality, rather than water volumes, it should not lead to double counting of water resources. As for acidification, our approach is to explore the link between current levels of emissions (in this case phosphate discharges) and the surface area of freshwater bodies which have phosphate levels exceeding the critical level.

Preliminary advice from the Soap and Detergent Industries Association suggests that the following approximations can be made:

- phosphate-based washing powders generally have phosphate content marked on the box (eg. 15-30%)

- the annual consumption of phosphate-based household detergents in the UK is about 60-64,000 tonnes of sodium tri-polyphosphate (in varying states of hydration), which is equivalent to about 15,000 tonnes of elemental phosphate

- detergents typically account for 15-20% of phosphates in the aquatic environment (with about 50% arising from agriculture and 30-35% from human wastes, industrial discharges and other sewage inputs)

For these purposes, we will have to neglect the variation between different water bodies, their proximity to sewage treatment plants, their sensitivity to eutrophication and so on. Taking a broad average across the country, we have to assume that each tonne of elemental phosphate used by households contributes approximately (17.5%/15,000) or 0.0012% of the overall eutrophication in the country.

The total area of inland water in the UK is 3,218 square km (*UK Annual Abstract of Statistics*) of which 758 square km are in England. Freshwater sampling data collected by the Environment Agency (*The UK Environment)* indicates that levels of orthophosphates exceeded 0.5 mg/litre at more than 50% of sampling points in the North West, Severn Trent, Yorkshire, Anglian, Thames, Southern and Western regions. The incidence of high orthophosphate levels was significantly lower for Northumbria (20-30%), the South West (0-10%), Wales 10%) and Scotland (0-10%). This corresponds quite well with monitoring of blue-green algae, one of the main symptoms of eutrophication. Environment Agency data suggests that (with variations between the regions) about 50% of waters sampled in the 1994 blue-green algal reactive monitoring programme in England had algae blooms or scums present. Despite the low orthophosphate levels in the South West, blue-green algae were present in a significant proportion of samples. Given that the orthophosphate level in the above data is more than three times the critical load used in the *Eco-Indicator* study, it seems conservative to assume that 50% of freshwater bodies in England exceed the critical load, and that this poses a threat to bio-diversity in these waters.

We therefore propose that eutrophication effects are regarded as minimal for households living in Wales, Scotland and Northern Ireland, but that the bio-diversity impact of detergent use is calculated as follows for households in England:

- 1 tonne of phosphate (active ingredient) affects 0.001% x 50% x 758 x 100 hectares of water-based bio-diversity reserve

ie:

- **1 kg of phosphate (active ingredient) affects an estimated 0.00038 ha of (water based) bio-diversity reserve.**

(Note that the contribution per tonne has been adjusted downwards from 0.0012% to 0.001% to account for the fact that detergent consumption by households in Wales, Scotland and Northern Ireland should not be attributed to England).

It is worth noting that, as for acidification, measures can be taken to reduce the impact of phosphate emissions. Where phosphate from domestic sources is a major contributory factor to a local eutrophication problem, the installation of phosphate removal facilities at existing sewage treatment plants can remove 90% or more of all phosphates reaching the plant. The EC Urban Wastewater Treatment Directive (91/271/EEC) will require these facilities to be fitted to all medium and large sewage works in areas with eutrophication problems. However, the UK has been slow to apply these techniques in all but the most sensitive areas.

A further point to note is that phosphate substitutes have their own impacts on the environment (eg. increased tendency to generate salts of aluminium and increased levels of surfactants which also contribute to eutrophication). This is taken into account in considering the impacts of different types of detergents within 'shopping activities'.

4. IMPACT OF TRANSPORT ACTIVITIES

4.1 General Comments

Fairly good data is available for the environmental impact of transport. The data we have used comes mainly from the Transport Statistics of Great Britain (TSGB, 1996) and the Royal Commission for Environmental Pollutions's report on Transport and the Environment (RCEP, 1994). Where not stated otherwise, consumption data refer to 1990 because a detailed breakdown of emissions by vehicle type are available for this year in TSGB and the RCEP report. Some transport emissions coefficients are prepared each year prepared as part of the National Atmospheric Emissions Inventory at the National Environmental Technology Centre, AEA Technology. However, these do not currently give a full breakdown by vehicle type.

Additional data by vehicle type has been drawn from German statistics presented in John Whitelegg's book 'Transport for a Sustainable Future' (1993). The original source for this data is the publication by U.Hopfner, reference 'Emissionsminderung durch rationelle Energienutzung und emissionsmindernde Massnahme im Verkehressektor' (1989); Bericht fur die Enquete Kommission des Deutschen Bundestages, Institut fur Energie und Umweltforschung, Heidelberg'. In places, we have also used estimates presented in Wackernagel and Rees's book 'Our Ecological Footprint'.

4.2 Cars

The algorithms below are presented in terms of litres of fuel used per year. If users are to be asked about their car mileage (MILES) and fuel efficiency (EFF), then the first step in the algorithm would be to calculate fuel used as follows:

FUEL (litres) = MILES (miles) * EFF (miles per gallon) * 4.4561

(where 1 gallon = 4.4561 litres)

To keep the questionnaire simple, no distinction is made between petrol and diesel usage - the figures represent the observed average of these two fuels. If a household owns more than one car, then the above calculation would have to be repeated for each car.

The estimates of pollution reduction through use of catalytic converters are problematic: catalytic converters do not work well when cold. Although theoretical able to reduce sulphur dioxide, nitrogen oxides and VOC emissions by as much as 70-80%, savings will be much lower for short trips from a cold start. Problems with maintaining catalytic converters suggest that observed pollution reductions may be less than theoretical savings even under normal running conditions. We have not gone so far as to ask users to disaggregate their mileage into 'cold start' and 'warm running', but we have downgraded the savings achieved by catalytic converters to an estimated 50% of these pollutants. We have neglected the slight decrease in fuel efficiency which is observed when a catalytic converter is fitted.

Where the user makes significant use of taxis, these should be included in the MILES total. The Transport Statistics for Great Britain estimate that carbon dioxide emissions per passenger kilometre are double those from cars, so **taxi miles should be multiplied by 2 to give equivalent car miles.**

(a) *Global warming potential*

= FUEL *A * C / B (units - tonnes CO2)

where A = 2.8827 tonnes CO2/tonne fuel
(calculations: 19,700,000 tonnes carbon produced by cars in 1990; multiply by 44/12 to convert to tonnes of CO2; divide by total petrol and diesel use in 1990: 22,608,300 tonnes petrol and 2,449,500 tonnes diesel - from TSGB/RCEP)

B = 1,334 litres per tonne
(calculations: weighted average (by 1990 fuel use, TSGB) for petrol (1,354 litres) and diesel (1,182 litres))

C = 1.45 uplift for energy embodied in car, maintenance and road maintenance (source: Wackernagel & Rees)

(b) *Acidification*

= FUEL * A/ B

where A = 0.02905 tonnes of SO2 equivalent per tonne of fuel
(Calculations: The Eco-Indicator 95 report (NOVEM) estimates that 1 tonne of NOx has an acidification potential of 70% compared to the same weight of SO2. So the impact in SO2 equivalents for 1990 is:
(23,310 tonnes SO2 + 0.7 * 1,006,720 tonnes of NOx) / 25,057,800 tonnes of fuel) - source TSGB).

B = 1,334 litres per tonne (as above)

With a catalytic converter, A should be reduced by 50%.

(c) *Summer smog*

= FUEL * A /B

where A = 0.03131 tonnes of PCOP equivalents per tonne of fuel
(calculations: The Eco-Indicator 95 report (NOVEM) estimates that 1 tonne of VOC should be weighted by 0.398 to give 1 tonne of PCOP-equivalent in terms of contribution to summer smog. We assume a similar weighting for NOx. So the impact in PCOP equivalents for 1990 is:
0.398 * (1,006,720 tonnes NOx + 964,320 tonnes VOC)/25,057,800 tonnes of fuel) (source TSGB, 1990).

B = 1,334 litres per tonne (as above)

With a catalytic converter, A should be reduced by 50%.

(d) *Land*

While figures for roadspace are readily available, the proportion of road space attributable to cars is difficult to estimate. Some estimates are as high as 90%. Our estimate is rather lower, possibly because it does not take into account the space required for parking.

= FUEL * (A * B/ C)

where A = 805,375 ha (land occupied by roads)

B = 60% (% attributable to cars)
(based on weighted vehicle-km, where the weights are guestimates of relative road space occupied per vehicle as follows:

	weight	bill.vehicle-km 1990 (source: TSGB)
cars	1	335.9
goods vcles	5	29.1
buses	5	4.6
m/cycles	0.2	5.6
light van	1.5	35.7
total		410.8
weighted total		559.1)

C = 25,057,800 tonnes * 1,334 litres/tonne

(e) *Other effects*

While health effects are not included in the footprint measure, the following statistics were collected to provide information for 'hints and tips' on the impact of transport on public health.

i) *Road accidents*: There were 3,650 road deaths in Great Britain in 1994, compared to 345.7 billion vehicle kilometres for cars in this year (TSGB). The 1990 base year seems inappropriate in this case because there has been a 30% reduction in road deaths between 1990 and 1994. Car vehicle-kilometres represented 82% of all vehicle kilometres in 1994, so we make the approximation that road deaths are primarily attributable to cars rather than other vehicles. If the figure for MILES driven is available, we can calculate the contribution to road deaths as follows:

= MILES *0.62137* 3650/345,700,000,000

where 1 kilometre = 0.62137 miles

If the figure for MILES is not available, we need to use the fuel consumption data for 1990 in conjunction with accident data for 1994:

So contribution to road deaths

= FUEL*3650/(25,057,800 tonnes * 1,334 litres/tonne)

ii) *Winter smog:* Cars also contribute to respiratory problems caused by winter smog. The two main pollutants emitted by cars which contribute to this problem are sulphur dioxide and particulates. The Eco-Indicator 95 report estimates that particulates are equivalent to SO2 in terms of their weight-for-weight contribution to winter smog. In 1990, TSGB statistics suggest that cars generated 23,310 tonnes of SO2 and 4,080 tonnes of particulates, while consuming 25,057,800 tonnes of fuel.

4.3 Buses and coaches

(a) Global warming potential

Data for carbon dioxide emissions from buses in the UK are not readily available, but German data is available for 1987 (John Whitelegg, 1993), assuming an average load factor of 20% for public buses and 60% for coaches. The units for BUS are passenger kilometres per year.

Global warming potential (tonnes of CO2 equivalents)

= BUS *A * B /1000

where A = 0.048 kg per passenger km

B = 1.45 uplift for energy embodied in bus, maintenance and road maintenance (Wackernagel & Rees)

(b) Acidification

Data is available from RCEP on estimated emissions from buses in 1990. The calculation of SO2 equivalents is explained under Cars above.

Acidification potential (tonnes SO2 equivalents)

= BUS * A/ B

where A = (3,780 tonnes SO2 + 0.7 * 42,030 tonnes of NOx)

B = 46 billion (passenger kilometres)

(c) Summer smog

Data is available from RCEP on estimated emissions from buses in 1990. The calculation of PCOP equivalents is explained under Cars above.

Summer smog contribution (tonnes PCOP equivalents):

= BUS * A /B

where A = 0.398*(42,030 tonnes NOx + 11,480 tonnes VOC)

B = 46 billion (passenger kilometres)

(d) *Land*

The land attributable to buses is estimated in the same way as for cars.

Direct land use (ha)

= BUS * (A * B/ C)

where A = 805,375 ha (land occupied by roads)

B = 4% (% attributable to buses)
(based on weighted vehicle-km, where the weights are guestimates of relative road space occupied per vehicle as follows:

	weight	bill.vehicle-km 1990 (source: TSGB)
cars	1	335.9
goods vcles	5	29.1
buses	5	4.6
m/cycles	0.2	5.6
light van	1.5	35.7
total		410.8
weighted total		559.1)

C = 46 billion (passenger km)

(e) *Other effects: winter smog*

The health effects of winter smog are not included in the footprint measure. The two main pollutants emitted by buses which contribute to this problem are sulphur dioxide and particulates. In 1990, TSGB statistics indicate that buses generated 3,780 tonnes of SO2 and 6,800 tonnes of particulates, while generating 46 billion passenger kilometres.

4.4 Trains

(a) *Global warming potential*

Data for carbon dioxide emissions from trains in the UK are not readily available, but German data is available for 1987 (John Whitelegg, 1993), assuming an average load factor of 30%. The units for TRAIN are passenger kilometres per year.

Global warming potential (units - tonnes CO2 equivalent)

= TRAIN *A * B /1000

where A = 0.079 kg per passenger km (John Whitelegg, 1993)

B = 1.45 uplift for energy embodied in train, maintenance and track maintenance (extrapolated from road figures used by Wackernagel & Rees)

(b) *Acidification*

Data is available from RCEP on estimated emissions from trains in 1990. The calculation of SO2 equivalents is explained under Cars above.

Acidification potential (tonnes SO2 equivalents)

= TRAIN * A/ B

where A = (3,000 tonnes SO2 + 0.7 * 37,000 tonnes of NOx)

B = 33.4 billion (passenger kilometres, TGSB)

(c) *Summer smog*

Data is available from RCEP on estimated emissions from trains in 1990. The calculation of PCOP equivalents is explained under Cars above.

Summer smog contribution (tonnes PCOP equivalents):

= TRAIN * A /B

where A = 0.398 * (37,000 tonnes NOx + 9,000 tonnes VOC)

B = 33.4 billion (passenger kilometres)

(d) *Land*

The land occupied by rail services is estimated as follows:

land (hectares) per passenger km

= TRAIN * ((A +B)*C / D)

where A = 2,481 ha (land occupied by stations, yards etc)

B = 16,585 km (track) * 3m (estimated width) /10 (hectares)

C = 80% (estimated % land & track dedicated to passenger services - slightly less than % of train vehicle kilometres)

D = 33.4 billion (passenger kilometres)

(e) Other effects: winter smog

The health effects of winter smog are not included in the footprint measure. The two main pollutants emitted by buses which contribute to this problem are sulphur dioxide and particulates. In 1990, TSGB statistics indicate that trains generated 3,000 tonnes of SO2 and 7,000 tonnes of particulates, while generating 33.4 billion passenger kilometres.

4.5 Air travel

(a) Global warming potential

For short journeys (eg.European), the impact of air travel is dominated by the take-off and landing cycle. For long haul flights (eg. from UK to Asia or North/South America), this assumption is unlikely to be valid. We have found three estimates of CO2 emissions from air travel:

- British Airways estimate that 110 grammes of CO2 were produced per 'available seat kilometre' in their worldwide, mainline flying operations in 1995/96. The ration of 'available tonne kilometres' to 'revenue tonne kilometres' in this year was 1.44, so making the assumption that this ratio will be broadly valid for passenger traffic, we estimate that emissions per paying passenger kilometre was 0.16 kg. [Source: British Airways, Annual Environmental Report 1996 - Report of Additional Environmental Data; BA Report Number 9/96];
- German studies estimate that 0.00214 GJ of energy is used per passenger km or 0.180 kg of CO2 per passenger km, assuming a 60% passenger load factor [Source: from Germany, 1987 (Hopfner, 1989, Institut fur Energie und Umweltforschung, Heidelberg) - presented in John Whitelegg's book 'Transport for a Sustainable Future' (1993)];
- Dr.Mayer Hillman estimates that 1.8 tonnes of CO2 were emitted for a roundtrip by air from UK to Florida, based on aviation fuel used and typical aircraft seat occupancy for such flights [Source: Dr.Mayer Hillman, Addendum to Memorandum submitted to House of Commons Select Committee on Transport, Inquiry on UK Airport Capacity].

It is not clear what mixture of short and long-haul trips lies behind the British Airways and German data. These data do not enable us to distinguish the impact of take-off/landing cycle from the remainder of the trip. However, there is broad consistency between the 'per kilometre' figures: if the distance from London to Miami is (say) 5,000 km one-way, then Dr.Hillman's estimate is close to the German estimate of 0.18 kg per passenger km and fairly close to the BA figure of 0.16 kg per passenger kilometre. We propose to use the figure 0.18 kg per passenger km in our calculations of CO2 emissions. AIR is measures in passenger kilometres.

Global warming potential (units - tonnes CO2)

= AIR *A * B /1000

where A = 0.180 kg per passenger km (J.Whitelegg, 1993)

B = 1.45 guestimate for uplift for energy embodied in aircraft, maintenance and airport maintenance (extrapolate from road figures put forward by Wackernagel & Rees)

(b) *Ozone Depletion Potential*

There is great debate about the impact of aeroplane exhausts at different heights on the ozone layer. Proponents of the air industry claim that flying in the troposphere contributes to chemical reactions which help to replenish ozone, while environmental campaigners claim that higher-level flying in or near the stratosphere has a serious ozone-depleting effect. Given the uncertainty of scientific knowledge about the impact of air travel on ozone depletion, we have omitted it from the impacts considered here.

(c) *Acidification*

UK data are available on the typical emissions of air pollutants in the take-off and landing cycle:

SO2	0.79 kg
NOx	18.5 kg
VOC	11.3 kg

Data are also available from two sources on typical emissions of pollutants per passenger kilometre:

- The German data presented by John Whitelegg estimate emissions as follows (assuming 60% passenger load factor): 0.00071 kg of NOx and 0.00031 kg of VOC per passenger kilometre.(excluding sulphur dioxide).

- British Airways data indicate that average emissions per available seat kilometre in 1995/96 were 0.04 grammes of unburnt hydrocarbons (VOCs), 0.43 grammes of nitrogen oxide and 0.03 grammes of sulphur dioxide. Making the assumption that we can translate 'available seat kilometre' to 'revenue seat kilometre' by applying the observed ratio for total tonnage carried (see above), we estimate that emissions per revenue seat kilometre were: 0.000058 kg of VOCs, 0.00062 kg of NOx and 0.000043 kg of SO2.

The slightly lower figures derived from BA data may be attributable to the higher load factor applied (the ratio of 1.44 is equivalent to a load factor of 69%). The difference in estimates of VOC emissions may be due to different definitions of VOCs. Neither source of data gives a breakdown between short and long haul trips. We have used the German data on emissions per passenger km, neglecting emissions of sulphur dioxide.

Acidification potential (tonnes SO2 equivalent)

= AIR * A/ 1000

where A = (0.7 * 0.00071 kg NOx) (John Whitelegg, 1983)

(d) *Summer smog*

As for acidification, this is based on estimates from German data (John Whitelegg, 1987):

Summer smog potential (tonnes of PCOP equivalent)

= AIR * A /1000

where A = 0.398 * (0.00071 kg NOx + 0.00031 kg VOC)

(e) *Land*

The estimate of land use attributable to air travel is based on the number of landings and take-offs.

Direct land use (hectares)

= TRIPS * A*B/C

where A = 8,361 ha (land occupied by airports)

B = 50% for passenger traffic (guestimate)

C = 75 million passenger journeys (UK airlines)

5. IMPACT OF ENERGY ACTIVITIES

5.1 General comments

Data availability on the direct environmental impacts of energy activities is fairly good. Most of the information presented here is derived from the Digest of UK Energy Statistics (DUKES, 1996), with supplementary data based on Friends of the Earth estimates. The year of 1994 is used as the base year for pollution and consumption data.

Data on indirect impacts such as land and water use by the energy industry were not, however, easy to obtain. We were, however, able to estimate water use by the electricity sector.

5.2 Gas

(a) Global warming potential

Global warming risk comes both from emissions of CO2 and from direct leakage of methane, which has a higher global warming potential. Gas consumption (G) is measured in kilo Watt hours (kWh).

Global warming potential: (units - tonnes CO2)

= G* (A+B)/1000

where A = 0.198 kg per kWh (source: FoE, 1989)

B = 0.00576 kg of CO2 equivalent for methane losses (calculations: Data from 1994: 411,000 tonnes emissions for gas leakage and domestic/commercial combustion of gas; approx 42% of gas attributable to domestic sector; multiply methane by 11 to convert to CO2 equivalents; divide by 28,355,000 tonnes of oil equivalent (ie. 329,768,650,000 kwh) - total domestic sector consumption in 1994)

(b) Acidification

Acidification potential (tonnes of SO2 equivalent)

= G * A*B/ C

where A = 0.7 * 142,000 tonnes of NOx (emissions from natural gas in 1994)

B = 42% (domestic)

C = 329,768,650,000 kWh (total domestic sector gas consumption, 1994) *(c)* *Summer smog*

Summer smog potential (tonnes of PCOP equivalent):

= G * A*B/ C

where A = 0.398 * 142,000 tonnes of NOx (emissions from natural gas)

B = 42% (domestic)

C = 329,768,650,000 kWh (total domestic sector gas consumption, 1994)

(d) *Land*

No data readily available.

5.3 Electricity

The estimates for impact of electricity are averages across the electricity supply industry as a whole, which effectively give an average across different sources of generation. Electricity consumption (E) is measured in kilo Watt hours per year (kWh).

(a) *Global warming potential*

Global warming potential (units - tonnes CO2)

= E* (A)/1000 (units - tonnes CO2)

where A = 0.832 kg per kWh (Source: FoE, 1989)

(b) *Acidification*

Acidification potential (units - tonnes SO2 equivalent)

= E * A/(B*C)

where A = (1,759,000 tonnes of SO2 + 0.7 * 526,000 tonnes of NOx) (total emissions from power stations, 1994, DUKES)

B = 305.85 TWh (total electricity supplied), 1994)

C = 1,000,000,000

(c) *Summer smog*

Summer smog potential (units - tonnes PCOP equivalent)

= E * A/(B*C)

where A = (526,000 tonnes of NOx + 6,000 tonnes of VOC)

B and C as for acidification

(d) *Land*

There is no practical way of estimating land use by the energy industry in the UK in the time available. While DoE is currently preparing an inventory of the stocks of land used for different purposes, most land use surveys have hitherto concentrated on changes in land use. The only way of accessing reliable data about land use in the energy industry would be to address queries to the major suppliers in each sector (electricity, gas, oil etc). As this has not been feasible in the timescale allowed for this project, we recommend that the direct land impacts of the energy industry should be neglected. See also notes on 'Impacts of Water Use' for comment on land use for reservoirs.

(e) *Water resources*

The electricity generating industry in England and Wales uses 12,612 megalitres of water per day. The 'water resource' impact of electricity use (E) is estimated as follows:

indirect water use ('000 litres) in electricity use

= E * A/(B*C)

where E = electricity consumption (kWh)
A = water consumption by electricity generation industry (England & Wales) in '000 litres per year
= 12,612,000 * 365 kl per year
(Source: The UK Environment)

B = total electricity supplied in UK
= 314.780 * 10^9 kWh per year (1995)
C = electricity generated in England and Wales as % of electricity distributed in UK estimate from % of electricity distributed, for which figures are available
= (279,693- 7,700 - 20,822 - 6,624)/279,693 =87%)
= say 85% (since % of electricity generated in England and Wales slightly lower than % distributed owing to imports from Scotland and Northern Ireland.)
(Source: Digest of UK Energy Statistics, 1996)

(f) *Other effects - winter smog*

The eco-calorie model does not currently quantify the health effects of winter smog. The power generation sector's total contribution to winter smog in 1994 was emissions of 1,759,000 tonnes of SO2 and 19,000 tonnes of particulates (source: DUKES). These emissions relate to total electricity supplied, not just the domestic sector.

5.4 Coal

Coal consumption (C) is measured in tonnes. Consumption should include coal substitutes such as smokeless fuel.

(a) *Global warming potential*

Global warming potential

= C* (A*B)/1000 (units - tonnes CO2)

where A = 0.586 kg per kWh (Source: FoE, 1989)

B = 8,445 kWh per tonne
(calculation: 30.4 GJ/tonne of domestic coal (DUKES); 1 GJ = 277.8 kWh)

(b) *Acidification*

Acidification potential

= C * A

where A = 0.023 tonnes SO2 per tonne of coal burnt (calculated from total coal consumption (DUKES) and total emissions from coal - Digest of Environmental Statistics (DES))

(c) *Winter smog*

Winter smog potential (units - tonnes SO2 equivalent)

= C * A

where A = (0.023 tonnes SO2 + 0.0032 tonnes particulates) per tonne of coal burnt
(calculated from total coal consumption (DUKES) and total emissions from coal - Digest of Environmental Statistics (DES))

(d) *Land*

No data readily available.

5.5 Heating Oil

Heating oil consumption (O) is measured in tonnes.

(a) *Global warming potential*

= O* A* B*C/1000 (units - tonnes CO2)

where A = 0.302 kg per kWh (Source: FoE, 1989)

B = 46 GJ/tonne heating oil

C = 277.78 kWh/GJ

(b) *Other impacts*

As an approximation, we have assumed that acidification and winter smog impacts are equivalent to coal on a tonne-for-tonne basis. It is possible that further data on emissions from heating oil in the domestic sector could be obtained in future from the National Air Emissions Inventory prepared by the NETCEN, AEA Technology.

5.6 Liquid petroleum gas (LPG)

Consumption of bottled gas (propane or butane) - also known as liquid petroleum gas (LPG) - is measures in litres.

(a) *Global warming potential*

Global warming potential = LPG * A * B/C

where A = 1.874 kg carbon per therm (source: National Air Emissions Inventory, AEA Technology)

B = 3.667 (to convert 1kg of carbon to carbon dioxide)

C = 3.98 litres per therm (source: Calor Gas)

(b) *Acidification*

Acidification potential = LPG * A * B/C

where A = 0.00485 kg nitrogen oxide per therm (source: National Air Emissions Inventory, AEA Technology)

B = 0.7 (to convert NOx to SO2 equivalents) (source: Eco-Indicator, 1995)

C = 3.98 litres per therm (source: Calor Gas)

(c) Summer smog

Summer smog potential = LPG * (A+B)*C/D

where A = 0.00485 kg nitrogen oxide per therm (source: National Air Emissions Inventory, AEA Technology)

B = 0.00019 kg VOC per therm (source: AEA)

C = 0.398 (convert to PCOP equivalents) (source: Eco-Indicator, 1995)

D = 3.98 litres per therm (source: Calor Gas)

6. IMPACT OF WATER USE

6.1 General comments

Households which have water meters will be able to measure water consumption (W) directly, but most households will have to construct an estimate of consumption. The volumes of water (in litres) used by typical activities are estimated by Thames Water as follows:

- dishwasher cycle (40 litres)
- clothes wash cycle (90 litres)
- toilet flush (9 litres)
- bath (110 litres)
- shower (30 litres)
- 1 hour of hose or sprinkler use (500 litres)

The Water Services Association provides water consumption estimates which are similar to the above with the exception of hose/sprinkler use. We have used a figure of 1000 litres for hour for hose/sprinkler use which is taken from the WSA publication 'Water Facts'.

The eco-calorie model allows the user to input their water consumption directly (if metered) or to make an estimate using the above coefficients. Water consumption (W) is measured in '000 litres per year.

(a) *Global warming potential*

The energy consumption of the UK water supply industry in 1989 was 140.6 million therms (4,121 GWh). This level of consumption had been fairly stable since 1979 and it is fair to assume that it will not have changed dramatically in the intervening years. Data is not readily available for energy consumed in sewage treatment works.

In 1989, 118.5 million therms (ie 84%) of this energy was supplied by electricity. Other fuels, such as gas, fuel oil and coal, represented a declining proportion of the energy supplied: decreasing from 35% in 1979 to 16% in 1989. For the purposes of this analysis, we will make the approximation that all of the energy consumed by the water supply industry is currently supplied by electricity.

On this basis, the electricity (kWh) used to supply 1,000 litres of water (E) is estimated as follows:

$$E = 1{,}000 * A/B$$

where A = energy consumed by water supply industry in UK in 1990
= $4121*10^6$ kWh
(Source: Energy Paper 64, Industrial Energy Markets, DTI)

B = public water supplied in UK in 1990/91 (excludes abstractions by agriculture, industry, electricity generation and others)
= $20{,}361*10^6*365$ litres
(Source: Waterfacts '96, Water Services Association)

so E = 0.55 kWh

The Global Warming Potential per '000 litres of water consumed can then be calculated as follows, using the coefficients from the Energy algorithms:

GWP = W * E * A/1000 (tonnes CO2)

where W = water consumed ('000 litres per year)
E = 0.55 kWh/'000 litres
A = 0.832 kg CO2 per kWh electricity

(b) *Land*

It has not been possible to estimate the land used by the water supply industry, for similar reasons to those given above under 'Impacts of Energy Use'. Much of the land owned by water companies (and/or hydro-electric companies) is used for reservoirs and their related catchment areas. Many of these water bodies and their surrounding land provide opportunities for public access and recreation, as well as having value for ecology. We therefore feel that it is reasonable to omit the 'land use' footprint of the water industry.

(c) *Water resource impact*

The quantity of water used by a household (W), measured in '000 litres, translates directly into a water resource impact.

We gave serious consideration to the question of whether water resource impacts should be included for households living in areas which are not drought prone. Recent drought records suggests that all of the water supply areas in England and Wales (with two exceptions: Anglia and West Water) have issued drought orders in the past 5 years (source: Water Facts 1996). Even in the non-drought areas, there is evidence of low flows in certain rivers (source: Digest of UK Environmental Statistics). Advice from the Scottish Office and Northern Ireland indicate that the whole of Northern Ireland has had a drought order in the past 5 years and that parts of Scotland have had hosepipe bans (eg. Highlands, Fife). Even in Dumfries and Galloway, an area of high rainfall, a hosepipe ban was considered in 1995. We therefore think that it would be reasonable to include water resource impacts for all parts of the UK.

(d) *Other effects - chemical use*

One of the potential health impacts of the water industry is chemical use in water and sewage treatment. A number of papers have been published on the use of chlorine by the water supply industry (eg. chapter on chlorine in 'Material Concerns' by Tim Jackson, University of Surrey; paper by Greenpeace 'The product is the poison - the case for a chlorine phase-out' (1991)). However, full data on chemical use by the water supply industry are not publicly available. This data could theoretically be collected from each water supply company in turn, provided that the companies were willing to release such data. This has not been possible within the timescale of this project.

(e) Other effects - acidification

Given the relatively low rate of energy consumption per unit of water supplied, the air pollution effects caused by electricity inputs to the water supply industry can be neglected.

7. IMPACT OF SHOPPING

7.1 General comments

In 1994 consumer expenditure, excluding: i) items dealt with under other activity categories, ie. fuel, power and running costs of transport; and ii) direct transfers, ie. rents, rates, education, betting & gaming, domestic service, was as follows:

	£m	%
Food	47381	17.2
Alcoholic drink	25774	9.4
Tobacco	11006	4.0
Clothing & Footwear	24693	9.0
House maintenance (DIY + contractors)	11467	4.2
Household goods	21874	8.0
Cars, motorcycles & other vehicles	21301	7.7
Recreation and entertainment	28598	10.4
Other goods & services	82995	30.2
TOTAL	275089	100.0

Source: Annual Abstract of Statistics

We are focusing on the categories of expenditure which are greatest in terms of (a) scale and (b) potential environmental impact. This section therefore focuses on:

- food purchases (including alcohol and tobacco);
- other high impact household goods:
  - paper
  - paints,
  - cleaning materials
- household appliances;
- hotel services.

Some other high impact goods (peat, hardwoods, construction materials) are included in the Chapter on House and Garden. The purchase of vehicles is already included in Transport Activity calculations through an uplift on vehicle use. We do not include textiles such as clothes and footwear, on the assumption that impacts are fairly small compared to food. With the exception of hotel services, recreation, entertainment and other services are excluded because the purchaser has little control over the environmental impact of these types of consumption.

7.2 Food purchases

According to figures in *Farming for the Future* - Cowell & Clift, a high proportion of food consumed in the UK is produced in the UK. So we use UK production as a proxy for environmental impact for all food consumed in the UK, but add on extra impacts for the transport of imported foods.

We considered dividing food into two categories: processed and unprocessed, but found that the impacts of processing were insignificant compared to transport impacts. This distinction is not therefore used here.

Our definition of 'food' includes alcohol, tobacco products and food purchased from restaurants and takeaways. We propose to treat take away food and meals out as processed food from the UK. The higher cost of pre-prepared food will (probably more than) compensate for the purchase of cooking and heating fuel via the item rather than in own home. Vegetables grown at home do not need to be included in the 'food' total, provided that the land they occupy (eg. private garden or allotment) is counted under 'direct land impact' (see Chapter 8).

To get a figure for the environmental impact per £ of expenditure on food, we sub-divide expenditure into food <u>harvested</u> in UK, rest of Europe, rest of the World (sea freight) and rest of the World (air freight). (It is where the raw produce is harvested that matters, even if, like tobacco, it may be processed in the UK). Anything with a mix of sources (vegetable soup!) gets treated as if it all comes from the furthest point of any of its products.

To calculate the impact of these different source categories, we:

- use figures from the recently published UK Environmental Accounts to derive estimates of environmental impacts per £ of purchases from the Agriculture, and Distribution sectors in the UK (excluding Food Processing because this is negligible);

- add estimates of the eutrophication impact of fertiliser use in agriculture (not included in the UK Environmental Accounts) from figures provided by ADAS;

- adjust eutrophication impact downwards for food from less-intensive agricultural systems outside the UK - in proportion to typical fertiliser use based on figures provided by Friends of the Earth;

- adjust land use upwards for food from less-intensive agricultural systems, using the simplistic assumption that yields per hectare vary in proportion to fertiliser use;

- add estimated transport impacts per tonne for products harvested outside the UK (using emissions per tonne-km estimates in 'Transport for a Sustainable Future', John Whitelegg, 1993 and guestimates of typical distances travelled). Assume that transport of food within the UK is covered by emissions from the Distribution sector.

- convert 'per tonne' to 'per £' figures using a weighted average of current food prices, weighted by average consumption figures, with an adjustment for packaging (from Social Trends and Annual Abstract of Statistics).

Some limitations of this approach are that:

- people eating cheap food get good scores, but cheap food may be produced by more damaging methods;

- people starving themselves get good scores. (By contrast the approach used in a Norwegian life-cycle analysis is based on getting a nutritious intake and minimising environmental impact);

- the impact of fishing industries is ignored, because environmental impacts are based on agriculture;

- going back up the 'life-cycle' chain, this approach does not capture the environmental impact of the manufacture of capital equipment used by these sectors, eg. tractors, fridges (although it does cover the impact of their use);

- the differences between intensive and extensive agriculture are not modelled in detail. Yields per hectare will not, in practice, vary in proportion with levels of fertiliser use. Also, figures for typical fertiliser use in developing countries may underestimate the intensity of the export agriculture sector. For example, while agriculture in Kenya is generally extensive, the production of green beans for export is likely to use intensive agricultural methods.

- the differences between processed and unprocessed food are ignored;

- the approach does not allow detailed modelling of different environmental impacts of agricultural production in different countries (eg. the category of 'food from Europe' covers food from agricultural systems as diverse as those in Denmark and Greece).

Adjustments can be made for lower impacts of organic food and the higher impacts of meat products. Norwegian life-cycle studies of organic food only reduce environmental food-points from 200 to 180 (SIFO report p13.) This implies that the benefits of organic food may be more health than environment-related. We propose to reduce the impacts of by 180/200=90%.)

The Norwegian studies state that the change from meat to vegetables is much more environmentally significant than changing to organic, reducing food impact from 200 to 120 food points. (SIFO report p13). We propose to multiply by the impacts of meat products by 200/120 (ie. increase by 66%).

The following table presents the factors by which expenditure on food (measured in £ per year) should be multiplied to give the estimated impact of food purchases. The assumptions underlying these figures are documented in spreadsheet form in Appendix D.

Table 1: Impacts of food from different sources
(Assuming that food expenditure is measured in £ per year)

impact	Food from UK	Food from other Europe (assume transport 50km by sea; 500km by road)	Food from rest of the World - sea (assume transport 6,000km by sea and 1,000km by road)	Food from rest of the World - air (assume transport 6,000km by air and 1,000km by road)
global warming potential (kg CO2 equiv)	0.000591	0.054091	0.196591	0.3795913
acidification (kg SO2 equiv)	0.000014	0.000651	0.002114	0.0128243
eutrophication (kg phosphate equiv)	0.000146	0.000005	0.0000037	0.0000037
summer smog (kg PCOP equiv)	0.0000000	0.000110	0.000338	3.8009008
direct land use - biomass (ha)	0.0000004647	0.000001354	0.000001826	0.000001826

To assist householders in identifying whether food is likely to have arrived from the 'rest of the world' by sea or air, the Fresh Produce Consortium has provided the following guidelines on the types of products which are currently likely to be air-freighted to the UK:

- early season shipments of peaches, nectarines, apricots, plums, grapes from Chile and South Africa (for a short time in November);
- cherries from USA and Southern Hemisphere (including a small amount from Norway in late summer);
- berries (strawberries, raspberries, blackberries, blueberries etc) from the USA, Latin America and other countries in the Southern Hemisphere;
- pineapples from Ghana (although sea shipments are starting);
- exotic fruits (eg. guava, papaya, passionfruit, physalis, pitabaya, tamarilla, rambutans) - most mangoes will be sea-freighted but some may be air-freighted;
- asparagus from USA, Peru and Chile;
- baby corn from Thailand, Kenya and Guatemala;
- find beans and mangetout from Kenya, Zimbabwe, South Africa and Latin America;
- flowers grown outside Europe have to be airfreighted because of their short shelf life. For example, roses from Kenya or Colombia would arrive by air.

7.3 Paper products

We have focused on two high-volume uses of paper - newspapers and disposable nappies - since households are likely to have difficulty in estimating their total paper use. Toilet paper and kitchen rolls have not been included, despite the significant volumes consumed, because of the 'image' associated with questions on these topics.

Nearly all our virgin pulp is imported, mainly from Canada and Sweden. The Pulp and Paper Information Centre has 1993 figures for the sources of all pulp (ie. all paper) used in the UK:

11% virgin pulp from UK forests
34% imported virgin pulp
55% waste paper.

It is not clear whether the PPIC estimate of waste paper is post-consumer waste or includes paper industry offcuts.

Given the high level of virgin pulp imports from Canada, we have based our footprint calculations on the analysis of Canadian paper production presented in 'Our Ecological Footprint' by Wackernagel and Rees:

energy used in paper production = 61 megajoules per kg
virgin fibre requirements = 1.8 m^3 per tonne of paper (in addition to recycled fibres)
fibre production in average forests = 2.3 m^3/ha/year

Newspapers

The weight of a typical week-day broadsheet newspaper in the UK is around 0.2 kg. Tabloids weigh approximately half this (0.1 kg) while Sunday papers weight considerably more (say 0.4 kg).

The estimated energy consumed in buying a given number of newspapers per week (NEWS - stated in broadsheet-equivalents) is:

energy (kWh) = NEWS * number of weeks * weight per newspaper * energy content

where
number of weeks in year = 52
weight per newspaper = 0.2 kg (broadsheet equivalents)
energy content (kWh) = 61 MJ * 277.78/1000 (conversion to kWh)

The eco-calorie translates this energy figure into the three main impacts (global warming potential, acidification potential and summer smog potential) using the impacts per kWh for gas, assuming that gas is the marginal fuel for additional energy supplies.

The eco-calorie also includes the use of land to grow new fibres for newspaper consumption.

biomass land (ha) = NEWS * number of weeks * weight per newspaper * new fibre content per tonne/(1000*paper yield)

where
number of weeks in year = 52
weight per newspaper = 0.2 kg (broadsheet equivalents)
new fibre content per tonne = 1.8 m^3/tonne
paper yield = 2.3 m^3 per hectare
1000 = conversion from kg to tonnes

This calculation implicitly assumes that a given percentage of Canadian newspulp is derived from recycled fibres. In the UK, at least 40% of newspulp is now derived from post-consumer waste.

Nappies

The paper content of disposable nappies is made entirely from virgin pulp. The Women's Environment Network has undertaken a study of the life-cycle impact of disposable versus washable nappies, and concludes that washable nappies are significantly better for the environment.

Depending on the age of the baby, the typical weight of a dry disposable nappy is about 0.035 kg. The WEN study suggests that paper will constitute about 50% of the nappy weight.

The estimated energy consumed in buying a given number of disposable nappies per week (NAPPY) is therefore:

energy (kWh) = NAPPY * number of weeks * paper weight per nappy * energy content

where
number of weeks in year = 52
paper weight per nappy = 0.035 kg * 50%
energy content (kWh) = 61 MJ * 277.78/1000 (conversion to kWh)

The eco-calorie translates this energy figure into the three main impacts (global warming potential, acidification potential and summer smog potential) using the impacts per kWh for gas, assuming that gas is the marginal fuel for additional energy supplies.

The eco-calorie also includes the use of land to grow new fibres for newspaper consumption:

biomass land (ha) = NAPPY * number of weeks * paper weight per nappy * new fibre content per tonne/(1000*paper yield*new fibre adjustment)

where
number of weeks in year = 52
paper weight per nappy = 0.035 kg * 50%
new fibre content per tonne = 1.8 m^3/tonne
paper yield = 2.3 m^3 per hectare
1000 = conversion from kg to tonnes
new fibre adjustment = 68%

The non-recycling adjustment takes account of the fact that the new fibre content per tonne of paper for nappies is higher than the new fibre content of newsprint and other paper. On the basis that 32% of UK paper & board consumption is made from recycled materials (UK

Materials Statistics 1991, quoted by Oxfordshire CC), the new fibre required per kilogramme of nappies is scaled up appropriately (ie. divided by (100%-32%)= 68%).

7.4 Paints/solvents

Emissions of volatile organic compounds (VOCs) from domestic paints and solvents make a relatively small contribution to total emissions of VOCs in the UK. Estimates from the Department of Environment for 1994 indicate that domestic solvent use represented about 10.6% of total VOC emissions in 1994 (2,228,000 tonnes), compared to 37% for transport and 19% for industrial solvents (Minutes of Evidence to the House of Commons Environment Committee on Volatile Organic Compounds). Of the 233,000 tonnes of solvents used in domestic applications, about 66,000 were attributable to painting, 4,000 to adhesives, 88,000 to aerosol products and 77,500 to other non-aerosol products.

The British Coatings Federation advises that only about half of this 'domestic paint' is actually applied within people's homes, since the 'domestic' total includes painting of other institutions (eg. schools, hospitals, commercial premises) - the reason for this confusion being that there is no end-use breakdown of paints supplied to professional decorators. This implies that only (say) 33,000 tonnes of VOC per year are emitted by paints used in homes, equivalent to 1.5% of the national total.

Given that this percentage is low, and that other solvent-based household products are actually *more* important for VOCs than paint, **we recommend that the impact of VOCs from paint should be neglected.**

We do recommend, however, that 'handy hints' should include suggestions that people should:

- use low-solvent or water-based paints wherever possible
- dispose of excess paints to re-use schemes, where these exist, rather than letting them dry out in the garage or dumping them to landfill.

7.5 Cleaning materials and chemicals

We are potentially concerned with two environmental impacts from household cleaning materials: water pollution by phosphates or alternative 'detergent builders' and air pollution by solvent emissions (VOCs). Figures for the UK domestic market for cleaning materials are as follows.

Product group	Tonnes sold in 1995
Fabric washing detergents	600,000 (of which 73% powders, 27% liquids)
Fabric conditioners and softeners	190,000
Dishwashing detergents - hand	160,000
Dishwashing detergents - machines	30,000
WC products (excluding toilet blocks)	140,000
Surface cleaning products	65,000
Toilet soap	50,000

Source: Soap and Detergent Industry Association, Fact Sheet.

Fabric washing detergents

We focus primarily on fabric washing detergents, which represent around 50% of this total market. These are also the products for life-cycle studies are most readily available. About 50% of the UK market for fabric detergents use phosphate (in the form of Sodium Tripolyphosphate or STPP) as a detergent builder. Phosphate use has declined in recent years with the introduction of alternative builders, of which the most common is a combination of Zeolyte A and Polycarbonate (PCA). Many European countries have entirely moved away from phosphate-based detergents, on the grounds that they cause more serious environmental problems than their alternatives (eg. eutrophication of lakes and rivers). However, recent life-cycle studies comparing phosphate-based and zeolyte/PCA-based detergents suggest that, while phosphate-based detergents are more damaging per kg of active ingredient, the greater effectiveness of phosphate-based detergents in the wash means that smaller quantities need to be used and the overall impact on the environment is roughly equivalent (Source: The Phosphate Report, Landbank Environmental Research & Consulting, January 1994). The Water Quality section of the Environment Agency advises that there is still considerable scientific uncertainty about the environmental impacts of phosphate alternatives (eg. formation of aluminium salts from zeolyte A; possible oestrogen-like properties of certain chemicals). Another complicating factor is the potential for removing phosphate and other pollutants from waste water by enhancing treatment at sewage treatment works: the EC Urban Waste Water Directive will require medium and large-scale sewage plants to invest in processes which remove about 90% of phosphates.

Given these uncertainties about whether phosphates are really better or worse for the environment than their alternatives, we propose that the footprint of a washing dose of non-phosphate based detergents should be assumed to be roughly the same as an equivalent washing dose of phosphate detergents. The Phosphate Report estimates that 0.7kg of STPP achieves the same washing effectiveness of 1.0kg of zeolyte/PCA (after correcting for Ph levels). Whichever detergent is used, people should be encouraged to use the minimum dose which gives effective cleaning for their level of water hardness.

This brings us on to the question of the environmental impact of phosphate detergents. To calculate eutrophication impact, we need to calculate the elemental phosphate-equivalent content of typical washing powders. Standard phosphate-based washing powders typically contain 15-30% STPP, and each gramme of STPP is equivalent to 0.25 grammes of elemental phosphate. Assuming that, on average, washing powders contain 25% STPP, 1kg of washing powder is equivalent to 0.25 kg of STPP and 0.0625 kg of elemental phosphate.

The eutrophication impact of 1kg of phosphate-based powder is therefore equivalent to about 0.0625kg of elemental phosphate. [Applying the footprint calculations proposed for eutrophication, this translates into a footprint of 0.000024 ha per kg of powder.]

For non-phosphate based detergents, which are normally sold in concentrated powder or liquid form, we propose that the weight of product containing 1kg of detergent builders (normally zeolyte A/PCA) should be treated as equivalent to approximately 2.8 kg of phosphate-based powder (this being the weight of powder containing about 0.7 kg of STPP).

Other detergents

As all products for dishwashing by hand have, by law, to be highly bio-degradable, we propose that their impact is neglected. However, products for dishwashing by machine produce some of the same environmental impacts as fabric washing detergents - they may, in fact, be more environmentally damaging. One life-cycle analysis suggests that the STPP content of a phosphate-based dishwashing detergent (7.5g per 30g dose) is similar to that for fabric detergents. We therefore propose that **1kg of machine dishwashing detergent should be treated in the same way as 1kg of fabric washing detergent (with the proposed adjustment for non-phosphate based detergents).**

We propose that the impact of fabric conditioners, water softeners, toilet soaps and other personal toiletries be neglected.

WC cleaning products and other chemicals

We propose that strong acid products (eg. bleaches) and strong alkalis (eg. limescale removers) be treated as equivalent to garden chemicals or pesticides. Although the eco-calorie does not currently quantify the health impacts of these chemicals, we recommend that health hints are included for these household chemicals, emphasising their impact on the water system and (potentially) on bio-diversity.

Surface cleaners

The data on VOC emissions presented above (see Paints) suggests that 167,200 tonnes of VOCs per year are attributable to 'domestic' products other than paints and adhesives (both aerosol and non-aerosol based). As in the case of paints, it is possible that these figures include some use of solvent-based products by institutions and commercial organisations. Using the same adjustment as for paint, we could estimate that about 84,000 tonnes were directly attributable to products used in the home.

The household products responsible for VOC emissions are likely to include surface cleaners (where these include solvents or solvent-borne fragrances), air fresheners, personal toiletries and so on. However, the figures are difficult to reconcile: the total domestic market for surface cleaners is only 65,000 tonnes, compared to an estimated 84,000 tonnes of VOC emissions from these and other solvent-based products in the home. It is clear that products other than surface cleaners must be making a significant contribution to VOC emissions. As data on other solvent-based products is not readily available, we feel that it is not appropriate to VOC emissions from surface cleaners without including these other (unknown) products. **We therefore propose that the environmental impacts of surface cleaners are omitted.**

7.6 Appliances

The only domestic appliances for which full life-cycle data are available are dishwashers and washing machines. Eco-Label reports on washing machines and dishwashers provide the following comparisons for energy and water consumption during their manufacture, distribution, use and disposal. These figures assume an average life of 14 years for a washing machine and 13 years for a dishwasher.

	Production	**Distribution**	**Use**	**Disposal**	**Total**
Washing Machine					
Energy	4.1	0.3	95.5	0.1	100
Water	2.1	0.1	97.8	0.0	100
Dishwasher					
Energy	1.8	0.3	97.9	0.0	100
Water	3.4	0.6	96.6	0.0	100

Source: *Ecolabelling Criteria for Washing Machines*, UK Ecolabelling Board 1992. *Ecolabelling Criteria for Dishwashers*, UK Ecolabelling Board 1992.

Given the low proportion of energy and water use attributable to production and distribution, we propose that these impacts should **either** be neglected **or** should be factored in to overall consumption figures. For example, if we assume that ratio of energy use in different phases of product life is similar for other energy-using appliances (eg. fridges, kettles, electric heaters, lights) we could allow a general 'overhead' of 2-4% of consumption to represent the energy required to produce and transport all of the household's energy-using appliance. The overhead allowed for water would be much lower, as most water use does not involve complex appliances. As these percentages are fairly low, and likely to be within the margin of error on other measurements, **we propose that energy and water required for production and distribution be neglected.**

We propose, however, that the impact of CFCs and their substitutes in fridges and freezers should not be ignored. The figures below relate to two categories of fridge: CFC-based fridges and non-CFC-based fridges. Any new fridge bought after 1995 must be non-CFC-based since EC Regulation 3093/94 prohibited the sale of CFC-based fridges after 1995.

There are two main impacts of fridge disposal: global warming and ozone depletion. While global warming impacts are currently included in the eco-calorie footprint, the impacts of ozone-depletion are not currently included since many of these impacts are health rather than land-related. We present the following figures on ozone depletion so that appropriate comments can be made on the health impacts of different types of fridges.

CFC-based fridges

There are three figures for the CFCs contained in old fridges:

a) 150g Source: *Refrigeration and Air Conditioning Usage*, 1992
b) 120g Source: Engineer, Association of Manufacturers of Domestic Appliances
c) 60g CFC-12 (coolant), 15g CFC-12 (oil), 220g CFC-11 (insulation foam) Source: *Warmer Bulletin* January 1997, derived from a study of scrapped fridges in the Netherlands

There is obviously a big disparity in these figures. This may be because the first two refer to the initial charge whereas figures for (c) are derived from the end of the fridge's life when some of the CFC has already leaked. It is also possible that the first two figures do not include CFCs which are in the insulation. In fact these are the main cause for concern, since in nearly all cases when a fridge is disposed of the CFCs in the coolant will be removed for recycling or disposal, but the CFCs in the insulation will eventually be released.

We propose to take the figure of 220g CFC-11 for the insulants as the impact of disposing of a medium size fridge, plus an additional 60g CFC-12 if the coolant is not properly disposed of. Fridges and freezers range from about 150 to 350 litres capacity, so we define a medium size fridge as 250 litres capacity, a small fridge as 180 litres and a large fridge or fridge/freezer as 320 litres. The following table shows the ozone-depleting and global-warming impacts of small, medium and large fridges, prorating the volumes of coolant and insulation in proportion to capacity.

Estimated environmental impact of disposal of CFC-based fridge

	Small fridge (180l)	Medium fridge-freezer (250l)	Large freezer or fridge-freezer (320l)
Volume of CFCs released from insulation (all fridges)	160g CFC-11	220g CFC-11	280g CFC-11
ozone depleting potential (1g CFC-11= 1g CFC-equivalent)	160g	220g	280g
global warming potential (1g CFC-11 = 3,400g CO2 equivalent	544kg CO2	748 kg CO2	952 kg CO2
Volume of CFCs released from coolant (improper disposal)	43g CFC-11	60g CFC-11	77g CFC-11
ozone depleting potential (1g CFC-11= 1g CFC-equivalent)	43g	60g	77g
global warming potential (1g CFC-11 = 3,400g CO2 equivalent	305kg CO2	426kg CO2	547kg CO2

Non-CFC-based fridges

New fridges use HFCs or hydrocarbons for the coolant, and can contain HCFCs or hydrocarbons in the insulation. The Association of Manufacturers of Domestic Appliances (AMDA) argue that HFCs, like CFCs, will also be recycled on disposal. As yet fridges containing HFCs are not ready for disposal, so it is not possible to put this theory to the test. There are no figures for HFCs and HCFCs in fridges, although the AMDA engineer claims that quantities will be similar to that for CFCs. Using the Netherlands figures for coolant/insulation volumes, and assuming that the HFCs are not recycled, the environmental impact of a new fridge using HFCs and HCFCs on disposal could be estimated as shown below. The global warming and ozone-depleting impact of a hydrocarbon-based fridge would be negligible in comparison.

Estimated environmental impact of disposal of HCFC and HFC-based fridge

	Small fridge (180l)	Medium fridge-freezer (250l)	Large freezer or fridge-freezer (320l)
Volume of HCFCs released from insulation (all fridges)	160g HCFC (type not known)	220g HCFC (type not known)	280g HCFC (type not known)
ozone depleting potential (on average, 1g HCFC = 0.05g CFC-equivalent)	8g	11g	14g
global warming potential (on average, 1g HCFC = 1,105g CO2 equivalent	177kg CO2	243kg CO2	309kg CO2
Volume of HFCs released from coolant (improper disposal)	43g HFC (type not known)	60g HFC (type not known)	77g HFC (type not known)
no ozone depleting potential	0g	0g	0g
global warming potential (1g HFC= 2,800g CO2 equivalent	120kg CO2	168kg CO2	216kg CO2

For both CFC and non-CFC-based fridges, we propose that the impact of buying a fridge is spread over the life of the fridge (estimate 14 years, as for washing machines/dishwashers). So the impact per year is derived by dividing the appropriate figure by 14.

For simplicity, the footprint estimates for global warming are based on a medium sized fridge-freezer. These figures can be adjusted using the above tables if more detail is known about the size of the fridge/freezer. **The global warming impact per year - if coolant is safely recycled - is as follows:**

medium sized CFC-based fridge:
global warming potential = 748/14 = 53 kg CO2 equiv

medium sized HCFC/HFC-based fridge:
global warming potential = 243/14 = 17 kg CO2 equiv

If the fridge is not safely disposed of - coolant is released to the atmosphere - these figures increase to 84 kg and 29 kg respectively.

7.7 Hotel nights

'Catering and Hotels' is one of the bigger expenditure items (£36875 or 13.4% of total consumer expenditure). Expenditure on meals out, take-away sandwiches and so on are already included in 'food' expenditure. The environmental impact of (non-business) hotel nights should be added to water and energy consumption in the home. Estimates of impact per hotel night have been obtained from the International Hotel Environmental Initiative and the Building Research Establishment's Introduction to Energy Efficiency in Hotels, Energy Efficiency in Hotels (Energy Consumption Guide 36) and related Case Studies.

The sources above give a range of figures for different types of hotels, ranging from 'good' to 'fair' to 'poor' efficiency, and from 'luxury' to 'small hotel' standard. The figures below are based on the mid-point estimates for small hotels (fewer than 20 bedrooms). The figures for medium-size/moderate hotels are similar (up to 150 rooms).

Environmental impact	**Estimated consumption**
water consumption	400 litres per guest-night
gas consumption	53 kWh per room-night
electricity consumption	18 kWh per room-night

These figures should be multiplied by 1.5 for stays in luxury hotels - 3 star and above.. (Strictly speaking electricity consumption which should be multiplied by 2.0, not 1.5, if the hotel is air conditioned - but this is neglected for the sake of simplicity.)

These figures include resources used for catering, so meals eaten in the hotel during the stay need not be included in the 'food' total.

8. IMPACT OF HOUSE ACTIVITIES

8.1 Materials embodied in house or flat

During preparation of the eco-calorie algorithms, there has been considerable debate as to whether the 'sunk costs' of construction of a house or flat should be included in the assessment of a household's impact. On the one hand, the current occupier has little influence on this figure - except when choosing a new home. On the other hand, demand for housing space does (at the margin) generate demand for the construction of new homes, just as demand for public transport (which appears to be running irrespective of one's decision to use it) does - at the margin - generate demand for more bus and train miles.

Our recommendation is that embodied materials should, on balance, be included. As in our earlier proposals, we recommend that embodied energy is neglected for pre-1919 houses on the grounds that these houses were generally built from more local materials (ie lower environmental cost), were more durable (ie. impacts can be spread over a greater lifetime) and that they can be regarded as 'fully depreciated'.

We recognise that the energy/resources embodied in construction materials is only one element affecting the overall environmental impact of a house. There are trade-offs to be made between, say, the embodied energy of a material and its durability or its effectiveness in insulating a house during use. However, in this case, energy in use is already being measured in the 'energy' section of the eco-calorie, so it is legitimate to focus on the construction phase.

The only source of life-cycle study of houses which we have been able to trace is a study undertaken for Scottish Homes by Eco-Logica Ltd in association with Nick Williams, Aberdeen University (*Life Cycle Analysis of Housing, Scottish Homes Working Paper, September 1996*). This study compares the life-cycle impact of two designs of modern two-bedroom flat: one using a standard design and the other using an environmentally-friendly timber-frame design (Eco-Type I). The study gives quantities for the significant materials used in construction, and uses the eco-indicator methodology to derive eco-indicator scores.

Eco-Indicator Scores from Scottish Homes Study

Life-cycle stage	Standard design	Eco-Type I
Assembly Energy in use Disposal	13.9 109.0 0.486	3.92 27.3 0.0
Total	123.4	31.22

Since the footprint methodology uses different weights from the eco-indicator methodology, we have taken the material quantities from this study and applied embodied-energy figures for different materials provided by the Association for Environment Conscious Building (AECB). The AECB figures are derived from a number of sources and generally include an allowance for transport. This analysis, shown in Table 2, suggests that the materials in the standard-design flat have an embodied energy of about 45,338 kWh. Given that the flat has a floor area of 66 m^2 and an estimated life of 70 years, we have derived an estimated indicator of embodied-energy per unit floor area per flat-year of 10 kWh per m^2 per year.

Materials in standard flat (66 sq m)	mass (kg) (from Scottish Homes LCA)	embodied energy (kWh/tonne) (from AECB)
portland cement	11523	2200
red brick	6343	175
lime	79	minimal
steel reinforcements	162	3780
PVC window frames	348	45000
rockwool	399	6530
polystyrene insulation	272	0
ceramic tiles	401	minimal
total embodied energy		45,338 kWh
impact per sq m of floor		687 kWh/m2
impact over 70 year life		10 kWh/m2/year

Based on rough assumptions about the number of walls, floors or ceilings which are shared with adjacent properties, we have then adjusted this figure to apply to terraced houses, semi-detached and detached houses. The resulting embodied energy factors, per unit of floor area, are set out below.

Dwelling type (post 1919)	**Factor**	**Embodied energy per m^2 of floor area, spread over 70 year life**
flat	1.00	10 kWh/m^2/year
terraced house	1.33	13 kWh/m^2/year
semi-detached house	1.67	17 kWh/m^2/year
detached house	2.00	20 kWh/m^2/year

We suggest that the embodied energy should be treated as gas equivalents, consistent with the assumption elsewhere that gas is currently the marginal fuel for additional energy supply. This is an approximation as, clearly, at least some proportion of these figures is attributable to oil products used for transport.

Environmental Standard Award

The figures above apply to the standard building type, and can legitimately be reduced for new houses built to the latest environmental standards. BRECSU have recently introduced the 'Environmental Standard Award' for new houses. Qualifiying houses have to gain six mandatory credits and a further 6 out of 16 optional credits. Mandatory credits do not relate to embodied energy (eg. achieve low CO2 emissions in use; insulating foams blown with low-ozone depleting agents; all timber from managed regulated sources or reused; adequate storage for recyclable household waste; minimum emissions from treated timber, no asbestos and no lead in paint). However, the optional credits include timber frame construction, use of recycled materials and aggregate, all of which have implications for embodied energy.

Assuming that Environmental Standard Award houses meet the optional credits for timber frame and recycled materials, we propose that the embodied energy footprint of homes which meet the Environmental Standard Award should be scaled down by the ratio of the eco-indicator scores for standard and Eco-Type I houses in the Scottish Homes lifecycle study. Looking at the assembly stage only (since waste and energy in use are dealt with separately), data from Table X indicates that Eco-Type I houses have an impact which is 3.9 compared to 13.9 eco-indicator points (ie. 28% of standard). **The impact of a standard house should therefore be reduced by approximately 70% to obtain the estimated impact of a house built to the latest environmental standards.**

8.2 House maintenance/improvements

Materials used

Home maintenance only amounts to 4.2% of total expenditure, of which almost half is through contractors. This makes it difficult for consumers to judge the value and contents of materials used. A second difficulty is that people in rented accommodation have much lower expenditure on this item (usually just internal decoration). This should be reflected in the presentation of comparative data, so that they can compare their scores to equivalent non-owning households.

We have found two sources of information on the impact of different maintenance materials:

(i) Embodied energy figures for a range of materials, provided by AECB, as set out in the table below.

(ii) A life-cycle study by TRADA comparing the life-cycle impact of UPVC and timber replacement windows.

Estimates of embodied energy in kWh per tonne (source: AECB)

Examples of materials	**Average embodied energy (kWh per m3)**	**Average embodied energy (kWh per tonne)**
very high impact per tonne:		
aluminium	55,868	20,169
plastics	47,000	45,000
high impact per tonne:		
lead	157,414	13,900
copper	133,000	15,000
glass	23,000	9,200
timber window frames (with glass)	25-30,000	9-10,650
foamed glass insulation	751	6,530

medium impact per tonne:		
steel	29,669	3,780
cement	2,860	2,200
gypsum plaster/plaster board	900	890
engineering bricks	2,016	1,120
clay tiles	1,520	800
autoclave blocks	800	1,300
woodwool	428-900	1,426-3,000
imported softwood	7,540	1,450
low impact per tonne:		
ordinary (fletton) bricks	300	175
concrete	600-800	275-360
crushed granite	150	100
local slate or stone	450-540	200
clinker blocks	600	500
sand & gravel	45	30
homegrown wood	110-220	200
render	400	277
cellulose/mineral fibre insulation	133-230	0

These figures reflect typical energy use in production and distribution, so heavy materials which are normally supplied from local sources to keep costs low (eg. sand and gravel) come out with low embodied energy figures. No account appears to be taken of the solar energy required to produce timber, and no account is taken of other environmental effects (eg. land use for growing trees or excavating minerals or stone).

Given the complexity of applying the embodied energy figures for all the different types of materials set out below, we decided to focus on choice of replacement windows as the single house maintenance decision which has the most significant impact and greatest sensitivity to environmental considerations.

Replacement windows

The lifespan of replacement windows is assumed to be at least 30 years, so the householder is asked how many windows have been replaced with UPVC/aluminium (both very high energy materials) or timber (medium energy content) during the last 30 years. The standard size of a replacement windows is assumed to be 1.8m by 1.2m, so the number of windows should be translated into 'standard-equivalents' if they are much bigger or much smaller than this.

The TRADA life cycle study focuses on the *differences* between UPVC and timber frame windows, leaving out the elements (such as glass) which are common between the two. Since glass is a fairly energy-intensive material, this means that the total energy embodied in replacement windows of either type is understated by this study.

The comparative embodied energy for UPVC and timber frames (including initial paint used on wood frames) is:

UPVC	7872 kWh
timber	1024 kWh

This assumes that each window is 1800mm by 1200mm with a 600mm fixed light and two 1200 mm high casements. The wood is assumed to be European oak, but no allowance appears to be made for transporting either the timber or the UPVC components. No allowance is made for any difference in durability between the plastic and timber frames. We assume that the timber frame has to be painted an additional six times over its 30 year life (requiring energy of 104 kWh per time) to ensure that it remains in good condition. Given that the embodied energy content of aluminium is fairly similar to that of plastic (see data from AECB), we assume that the figures for UPVC frames would also apply to aluminium frames. The energy impact of the different frames is therefore:

Energy (UPVC/aluminium) = (number of UPVC/alum. frames) * 7872/30 kWh

Energy (timber) = (number of timber frames) * (1024 + (6*104)/30 kWh

The environmental impacts of the two types of frames (aluminium/UPVC and timber) are then calculated by assuming that the embodied energy is provided by electricity. We feel that electricity is more appropriate than gas in this case because of the use of electricity in smelting aluminium. There are four main impacts of electricity consumption: global warming potential, acidification, summer smog and water resource depletion.

For timber frames, we also add in the impact of land used to grow the timber. We use the estimates of timber footprint in Section 8.3 (source: IIED) which imply that 1 m^3 of sawn wood has a direct biomass footprint of approximately 0.34 hectares of forest in continuous production. Applying (approximate) conversion factors that 1 m3 of sawnwood weighs 1 tonne (based on wood density figures from the Association for Environment Conscious Building), and that a window frame made from European hardwood weighs about 100kgm we arrive at the following estimate for the biomass footprint of a timber window frame:

biomass land (ha) = number of windows * A * B * C/ (D*1000)

where
A = 0.34 hectares per m3
B = 1 m3 per tonne
C = 100 kg per window frame
D = 30 year life

8.3 Tropical hardwoods

Wood products - general

The International Institute Environment and Development (IIED) has undertaken a footprint analysis of wood-based products in general. They estimate the overall footprint of the UK's forest product imports to be the equivalent of 6,375,542 hectares continuously producing for the UK plus an additional 66,769 hectares of forest cut or severely degraded for the UK.

Total UK imports of different forest products are as follows, converted to roundwood equivalents using the generalised conversion factors applied by IIED (to compensate for the wood lost in cutting planks etc from round timbers):

Product type	UK imports ('000 m3)	Conversion to roundwood equivalents	UK imports in roundwood equivalents
industrial roundwood (coniferous)	108	100%	108
industrial roundwood (non-coniferous)	205	100%	205
chips, particles, wood residues	44	100%	44
sawnwood	7284	65%	11206
wood-based panels	2512	50%	5024
wood pulp	2155	75%	2873
paper & paperboard	6057	65%	9318
Total:			28,778

Therefore, on average, **0.22 ha of forest** is required in continuous production to meet an annual consumption of 1 m^3 of roundwood equivalents (0.22 = 6,375,542/28,778,000), in addition to 0.0023 ha of forest being cut or severely degraded.

Put the other way (and neglecting the forest permanently degraded):

- 1 m^3 of paper or paper products has a direct footprint of approximately 0.34 hectares of forest in continuous production.

- 1 m^3 of sawnwood has a direct footprint of approximately 0.34 hectares of forest in continuous production

- 1 m^3 of wood-based panels or plywood has a direct footprint of approximately 0.44 hectares of forest in continuous production.

These figures exclude the impacts of freight transport and other aspects of production or processing, on the assumption that these will be small compared to the direct footprint.

Tropical hardwoods

We propose that consumption of tropical hardwoods should be treated as a bio-diversity issue unless the wood is from forests certified by the Forest Stewardship Council (FSC). This is the only independent scheme which Friends of the Earth and the Department of Environment recommend as providing reliable assurance that the forest is being sustainably managed. The logic for treating tropical hardwoods as a bio-diversity issue, unless sustainably managed, is that some hardwoods take so long to regrow that logging may change the bio-diversity of the forest irreversibly. This is particularly the case in tropical forests where topsoil is thin and prone to erosion when trees are cut.

There are two estimates for the typical yield per hectare per year for tropical forests:

- IIED's estimate a sustainable yield of 2.0 m^3 per hectare per year for all wood from natural tropical forests;
- Friends of the Earth suggest a maximum yield of 0.46 m3 per hectare per year and a conservative yield of 0.26 m3 per hectare per year tropical forests (source: Out of the Woods, FOE, April 1995).

As these estimates vary quite widely, we propose using a compromise figure of 0.46 m3 per hectare per year (the FOE maximum estimate). Using this figure, **the bio-diversity footprint of non-FSC tropical hardwood is estimated to be 2.2 hectares per m^3.**

8.4 Peat

Our approach to peat is similar to that for hardwood. Commercial peat stripping destroys a type of habitat which is valuable for bio-diversity and is becoming increasingly rare. Peat bogs take thousands, rather than hundreds, of years to regenerate.

Advice from the peat campaign run by The Wildlife Trusts suggests that the typical depth of commercial peat stripping is 0.5 metres. Assuming that 1 m^3 of wet peat yields 0.5 m^3 of dry peat (guestimate), this means that one hectare of stripped peat bog yields 10,000*0.5*0.5 m^3 of dry peat (ie. 2,500 m^3 or 2.5 million litres). Data from Friends of the Earth suggests that a typical bog may grow to 1.5-2.0 m deep after 4-5,000 years, so 0.5 m would take about 1,300 years to regenerate, so the bio-diversity impact of any given year's consumption must be multiplied by 1,300.

This means that the **estimated bio-diversity footprint per litre of peat is 0.00052 hectares.**

8.5 Direct Land Use

This is the built-up land area (in hectares) occupied by the user's house or flat (including associated buildings, patios and driveways, green space and garden areas). The area should also include any surfaced road area dedicated to accessing the house or flat (or an appropriate share of this area). We debated whether private gardens, allotments and green areas should be included in the land use footprint, since there is a risk of double counting with carbon dioxide absorption (global warming effect). After consideration, we have included these areas within the direct land footprint, since they are analogous to the 'biomass land' used for growing food and timber. Indeed, if vegetables are grown at home then the garden or allotment will act as 'biomass land' for the household.

8.6 Second/holiday home

The questions on buildings and maintenance should be repeated for any holiday cottage or second home, scaled down as appropriate if the home is shared with other people.

9. IMPACT OF WASTE

9.1 General comments

At least 85% of all UK household waste which is sent for disposal goes to landfill (excluding the proportion which is recycled) (*Source: Externalities of Landfill and Incineration, HMSO, 1993).* Some sources put this estimate at 90-95%. We therefore suggest a simplifying assumption that all household waste is assumed to be landfilled. The methodology set out below could be extended to estimate the impact of incineration. This would have to take into account the facts that some older incinerators do not recover energy and that residual ash still has to be landfilled.

The tables below assume that household waste is measured in tonnes. Typical conversion factors to get from (uncompacted) volume to tonnage are as follows (source: advice from Torbay District Council):

- a conventional dustbin (steel/plastic) holds approximately 90 litres (uncompacted weight about 12 kg);
- a *full* black sack holds an equivalent amount (ie. 90 litres or 12 kg); but if the user only fills their sacks half or two-thirds full, this should be pro-rated down. A quick session with the bathroom scales would provide a good check!
- a *full* wheelie bin holds 240 litres (equivalent to about 30kg). However, the average weight of rubbish per bins is usually around 15kg, suggesting that many people fill them half-full or less. Again, the full weight should be adjusted downwards according to each household's behaviour.

9.2 Recycling

Recycling and home composting have the effect of reducing the quantity of household waste requiring collection and disposal. Recycling generally also reduces the loss of energy and other resources, assuming that the recycled materials substitute for primary materials in the production process. There are exceptions to this rule: short-term fluctuations in the markets for particular recycled materials may mean that some 'recycled' materials is disposed of to landfill rather than reentering the production cycle. Also, the energy required to transport, sort and reprocess some materials (eg. plastics) may in some cases exceed the energy required to produce primary materials.

Our analysis of recycling is restricted to elements of household waste which can usually be recycled cost-effectively at present: aluminium cans, glass, paper (not card), plastic bottles and steel/iron cans. This analysis would need updating if the market for these recyclables changes significantly, or if technological development changes the cost-effectiveness of recycling other elements of the waste stream.

Assuming that markets for these recyclables exist, and that recycling is energy and cost efficient, we need to estimate an 'energy/resource credit' for recycling which will partially compensate for the 'energy/resource loss' associated with use and disposal.

9.3 Impact of household waste disposal and recycling

We calculate the impact of waste disposal in three parts:

a) the impact of collection and disposal by landfill of net waste actually disposed of by the household (WASTE - measured in kg);

b) the potential resource loss if gross waste, including any materials recycled, were lost to landfill (apply factor 'GROSS_UP' to WASTE);

c) the resource credit from actual materials recycled.

This section also discusses the impact of composting (d).

(a) Impact of collection and disposal by landfill

Landfill	Waste disposed
Global Warming Potential (kg CO2 equivalent per kg waste)	= WASTE * (A + {BxC})/1,000,000 Where: WASTE = kg waste disposed (net of recycling & composting) A = g CO_2 equiv per tonne waste journey to disposal[a] = 1851 g/tonne in urban areas or = 15,914 g/tonne in rural areas B = g methane emissions per tonne household waste[b] = 33,000 g/tonne C = conversion of methane to CO_2 equiv (source: Eco-Indicator 1995)
Acidification (kg SO2 equivalents per kg waste)	= WASTE x 24.9[a] x 0.7[c] /1,000,000 (urban areas) = WASTE x 307.3[a] x 0.7[c]/1,000,000 (rural areas)

Degraded land	1 tonne of household waste occupies (roughly) 1 cubic metre of landfill void when compacted and decomposed.[e] Typical landfill site depths vary from 2-3m for landraise or sand & gravel pits up to 20m for other mineral workings (take 10m as typical figure).[e] This implies that one tonne of waste occupies about 1/10 of a square metre of landfill surface area - equivalent to 0.00001 hectares. However, almost all landfill sites involve reclamation of old mineral workings and the reclaimed land will generally have some ecological value. On a wholly arbitrary (but reasonable) basis, we could estimate that 50% of the footprint value is likely to be retained; we could then attribute 25% of footprint loss to minerals demand and 25% to waste disposal. This would imply that the land footprint of a tonne of household waste is of the order of 0.0000025 hectares. We propose that the footprint be multiplied by 100 to reflect that the impact lasts not just for one year but for tens or hundreds of years. The final footprint is 0.00025 hectares/tonne.

Sources:

a Externalities from Landfill and Incineration, HMSO, 1993.

b Externalities from Landfill and Incineration (for landfill without energy recovery from methane). The figure of 33,000 grammes of methane per tonne of waste is conservative compared to an estimate of 47,000 grammes per tonne of household waste provided by AEA Technology.

c *Life Cycle Assessment and Economic Evaluation of Recycling: A Case Study*, A. Craighill & J. Powell, Resources, Conservation and Recycling, Vol 17, 1996.

d convert NO_x to SO_2 equivalents

e estimates from SERPLAN, Oxfordshire County Council, Torbay District Council and CPRE

The eco-calorie indicator does not currently quantify the health effects of waste disposal, such as the contribution from landfill to winter smog (eg. through NOx emissions) or the effect of leachate on water quality. Although data is available on the number of pollution incidents, no data is currently available to estimate the relationship between the tonnage or type of waste landfilled and the likelihood of leachate pollution of surface or ground water.

(b) Potential resource loss if gross household waste were disposed to landfill

To calculate the resources lost if the recyclable materials listed in 9.2 were not recycled, we use estimates of the typical proportion of each material found in household waste dustbins. This avoids having to ask a large number of questions to determine how much of each material is used and, of that, what proportion is recycled. Where a household is recycling one or more of these materials, we use the typical proportions to 'back calculate' their implied total waste before recycling and composting.

Gross waste = (WASTE (kg))/(1-Rg*Pg-Ra*Pa - Rc*Pc etc)

where Rg = 1 if almost all glass is recycled (otherwise 0)
Pg = typical proportion of household waste which is glass (see Table on recycling below)

Ra = 1 if almost all aluminium is recycled (otherwise 0)
Pa = typical proportion of household waste which is aluminium

Rc = 1 if putrescibles are composted (otherwise 0)
Pc = typical proportion of putrescibles in household waste

(similar co-efficients for steel and plastics).

The resources lost if no materials are recycled are then calculated as follows:

Resource loss (energy - kWh) = Gross waste * (Pg*Eg+Pa*Ea+......)

where Eg = embodied energy per kg of glass etc

Estimates for both embodied energy (Eg etc) and typical proportions of recyclables in household waste (Pg etc) are given in the Table in section (c) below on recycling benefits.

The three main impacts of the energy resources lost (kWh) are then derived using the assumption that the energy loss is gas, on the basis that this is the least damaging of the energy options available:

Global warming potential = Resource loss (energy-kWh) * (Global warming potential per kWh gas)

Acidification potential = Resource loss (energy-kWh) * (acidification potential per kWh gas)

Summer smog potential = Resource loss (energy-kWh) * (summer smog potential per kWh gas)

For paper, we include the loss of productive land used to produce the paper:

Biomass land impact = Gross waste * (Pp*Lp)

where Pp = typical proportion of paper in household waste
Lp = biomass land required to replace lost fibre.

(c) Calculation of benefits of recycling

Estimates of potential energy savings from recycling are fairly widely available - those below are presented by Friends of the Earth in the 'Recycling Officers' Handbook' (1991). These savings are applied to estimates of total embodied energy per kg derived from information provided by Wackernagel and Rees (for paper) and the Association for Environment Conscious Building (for other materials). There is considerable debate on the validity of these embodied energy estimates. There is clearly also a question about how far estimates derived for building materials remain valid when applied to glass bottles, plastic bottles, aluminium cans and so on. We can probably assume that the embodied energy of these materials in packaging would, if anything, be higher than the figures set out here because of the additional processing required. In the case of paper, we also include an allowance for 'biomass' land, assuming that virgin pulp has to be substituted for the lost paper fibres.

Recyclable/ compostible material	readily recyclable materials as % of household waste (by weight)	embodied energy (kWh per kg)	bio-mass land used (hectares per kg)	% potential energy savings from recycling
Aluminium cans	Pa = 0.4%	Ea = 20.2	-	Sa = 96%
Glass	Pg = 9%	Eg = 9.2	-	Sg = 22%
Paper	Pp = 16%	Ep = 16.9	Lp = 0.0011	Sp = 70%
Plastic	Ppl= 2%	Epl=45.0	-	Spl= 97%
Steel/iron	Ps = 5%	Es= 3.8	-	Ss = 74%
Putrescibles	Pcomp = 20%	-	-	-

Data notes

1. Wackernagel and Rees estimate the energy content of paper to be 61 megajoules (MJ) per kilogramme. Applying the conversion ratio 1 GJ = 1000 MJ = 277.78 kWh, this is equivalent to 16.9 kWh per kg of paper.

2. Wackernagel and Rees estimate that 1.8m3 of virgin wood fibre are required to produce a tonne of paper in Canada, excluding recycled fibres. As a significant proportion of UK pulp is imported from Canada, it is not unreasonable to use these figures. If the recycled content of Canadian paper is equivalent to the UK (approximately 32% of paper consumption) then the total wood fibre requirement is estimated to be about 2.6 m3 per tonne. Wackernagel and Rees estimate that Canadian forests typically produce 2.3 m3 per hectare per year. A kilogramme of paper fibres therefore has a 'lost wood fibre' biomass footprint of (2.6/2.3)/1000 hectares per year, in addition to energy lost.

The benefits of recycling are calculated by adding back in some of the resources lost, using the percentage savings set out above. For example the energy saving from recycling glass is as follows:

$$\text{Energy saved (kWh)} = \text{Gross waste} * (Pg*Eg*Sg)$$

Again, the impact of the energy saved in kWh is converted to the three main impacts (global warming potential, acidification and summer smog) using the assumption that the energy used is gas.

For paper, we also estimate the biomass land use saved:

Biomass land saved (ha) = Gross waste * (Pp*Lp).

(d) Composting

If a household undertakes home composting, we assume that 20% of their gross waste is composted (see Table above on typical composition of household waste). We do not estimate any 'recycling benefit' for home composting since this should translate into a reduced need to purchase fertilisers or soil improvers for the garden (see chapter on House and Garden). We neglect any reduction in landfill impact (eg. methane production) through the removal of putrescibles from the waste stream.

9.4 Incorrect Disposal of Oil and Pesticides

(a) Oil

When disposed of down the drain, oil has a potentially damaging effect on the bio-diversity value of surface water. 1 gallon of oil can spread across the surface of 10,000 sq metres of water (*Source: Water Quality Section, Environment Agency*). So we can translate the impact of poorly-disposed oil into a negative impact on the 'water-based' bio-diversity reserve: 1 litre of oil can affect 10,000/4.546 = 2,250 sq. metres of water (ie. 0.0225 hectares of bio-diversity reserve).

(b) Pesticides

Any active chemical ingredients disposed of improperly (eg. down the drain) may have a potential health impact. This is not explicitly measured by the eco-calorie at present, but should be covered by health hints and tips.

9.5 Bulk disposals

We suggest bulk disposals are defined as once-off disposals of inert waste (ie. construction waste, furniture, appliances). Garden waste which is put out for disposal should be included in the household waste computations.

We then assume that bulk disposal waste is basically inert and that 1.5 tonnes of inert waste convert to 1 cubic metre of landfill void. We also assume that any items with reuse or recycling value are excluded from bulk waste. The impact figures for landfill are adjusted as follows:

Impact of inert waste disposal by landfill

Landfill	Waste disposed
Global Warming Potential	= BULK * A/1,000 Where: BULK = tonnes of bulk waste disposed of A = g CO_2 equiv per tonne waste journey to disposal[a] = 1851 g/tonne in urban areas or = 15,914 g/tonne in rural areas
Acidification	= BULK x 24.9[a] x 0.7[c] /1,000 (urban areas) = BULK x 307.3[a] x 0.7[c]/1,000 (rural areas)
Degraded land	1 tonne of inert waste occupies (roughly) 0.67 cubic metre of landfill void when compacted and decomposed.[e] Typical landfill site depths vary from 2-3m for landraise or sand & gravel pits up to 20m for other mineral workings (take 10m as typical figure).[e] This implies that one tonne of inert waste occupies about 0.067 of a square metre of landfill surface area - equivalent to 0.0000067 hectares. However, almost all landfill sites involve reclamation of old mineral workings and the reclaimed land will generally have some ecological value, On a wholly arbitrary (but reasonable) basis, we could estimate that 50% of the footprint value is likely to be retained; we could then attribute 25% of footprint loss to minerals demand and 25% to waste disposal. This would imply that the land footprint of a tonne of inert waste is of the order of 0.0000017 hectares. Again, this is multiplied by 100 to reflect the fact that the impact may last for hundreds of years, so the footprint becomes 0.00017 hectares per tonne of BULK.

Sources:

a Externalities from Landfill and Incineration, HMSO, 1993.

c *Life Cycle Assessment and Economic Evaluation of Recycling: A Case Study*, A. Craighill & J. Powell, Resources, Conservation and Recycling, Vol 17, 1996.

d convert NO_x to SO_2 equivalents

e estimates from SERPLAN, Oxfordshire County Council, Torbay District Council and CPRE

10. IMPACTS OF VOLUNTARY ACTIONS

10.1 Volunteer days:

We compared the *impact* of sample volunteer days and found a wide variation in their apparent effectiveness in reducing society's footprint. The following examples are derived from estimates of the effectiveness of different campaigns:

1 day campaigning for the National Cycle Network

- 1 volunteer day contributes to about 9 litres FUEL saving

1 day campaigning for WEN nappy laundry campaign

- 1 volunteer day contributes to savings of about 15 m^3 WATER (ie.15,000 litres) and 236kg WASTE and £150 purchasing)

Planting & management of new community woodland
on disused wasteland

- 1 volunteer day equivalent to 1 ha per year of biomass footprint, upgraded from built-up land (ie. reduces footprint by 1 ha)

FoE Peat campaign

- 1 volunteer day equivalent to 2 ha per year of biodiversity protected (ie. reduces footprint by 2.0 ha)

The wide differences exhibited here suggests that there is no simple 'average' for the impact of a volunteer day (footprint range from 0.001 ha to 2 ha per day!). Given these differences, and the complexity of asking households to estimate the real effectiveness of voluntary time spent, we decided to opt for a measure of voluntary *inputs* rather than *outcomes* or *impacts*.

Voluntary inputs should be measured simply by asking households how many days per year they spend on voluntary activities which promote a more sustainable environment.

10.2 Donations

After significant discussion with the Reference Group, we decided not to include monetary donations within the eco-calorie. Donations can be translated into volunteer day-equivalents with relative ease (according to environmental NGOs, £35 donation (after tax) = 1 day), but the Reference Group felt that donations should not be included for two reasons:

- monetary donations are much less beneficial than voluntary work from the viewpoint of awareness raising for the volunteer;

- it would be problematic to define which 'good causes' do or do not qualify as environmental (eg. people might include membership payments for organisations such as the National Trust).

10.3 Investment

We have been unable to get any information out of the ethical/environmental investment industry, environmental industries commission or trade associates which would substantiate any claim that investing in green funds achieves any improvement in environmental outcomes. We feel that it is inappropriate to include measures of impact for this activity, although advice on ethical investments could still be included in 'hints and tips'.

PART 3

COMPARISONS, TRANSITION POINTS AND HINTS

PART 3: COMPARISONS, TRANSITION POINTS AND HINTS

11. INTRODUCTION

This part of the work raises some quite tricky questions about apportionment, comparisons and how to present the data in ways that are motivating *and* free from distortions and misleading omissions. The material below follows the ideas in our fax to Craig Simmons of 28 January as modified by our subsequent phone conversation. We have set out the reasoning for some of the approaches we are proposing for the benefit of the Reference Group.

11.1 What do the comparisons 'control' for?

The basic footprinting calculation will show that living in colder locations, in the country, in a detached house, in an area of water shortage, with lots of kids (etc) does bring bigger environmental impacts. If we try to hide these facts we are trivialising and misleading.

However it would also obviously be unhelpful to present the figures in such a way that users were so paralysed with guilt over large impacts which they can't alter in the short term that they lose motivation to do the small things that are immediately possible. Or that there was so much dissonance between the message and users' perceptions that they reject the whole approach.

So our aim should surely be to raise users' awareness of both the 'tactical' and 'strategic' actions they can take. In other words we need to show that insulating the house well, avoiding waste of energy, water and packaging, getting the most fuel-efficient car, sharing it, using public transport (if and when there is any!), showering instead of bathing, bathing all the kids together, etc can reduce these impacts. But so can choosing (as and when the opportunity or option arises) to live in a terraced house, in a sheltered area, near to a range of amenities in a city.

We have argued that it would be seriously misleading to 'net out' of the comparison factors which are a matter of household choice, even if only over the longer term, such as where to live (rural vs urban), size and type of house - even number of children. Instead, comparative data should be chosen and structured to show how - whatever choices people have previously made - choices and changes available to them in the future, both short and long term, can *improve* their performance.

This has the following implications for aspects of the comparative data.

11.2 Household size

Household size is, at least over the longer term, a matter of lifestyle choice. The realisation that the projected need for 4 million extra homes is largely caused by predicted continuation of current demographic trends towards smaller households is making this become a very live issue for environmental policy - as witness John Gummer's 'great householders debate' and the TCPA's 'How Shall We Live?' investigation.

We therefore feel it will be important not to disguise the environmental 'economies of scale' which generally come from more people sharing a house - and garden, and car trips. So rather than using conversion factors between different household sizes that attempt to 'net this out' we suggest converting between different household sizes simply on the basis of the number of people in them, eg expect a 3 person household to have 75% of the impacts of a 4 person one. In general smaller households will have to try to harder to reach the same level of performance as larger ones. But we believe that's the 'right answer' to show: that's the way things are.

We suggest that the easiest way to show comparisons is on the basis of the *mean per capita impact* of each household. Particularly in the manual version of the measure we feel this would give all users a simple, easily comparable 'bottom line' number which will enable them to make comparisons with anyone else. (This obviously does not stop them searching out households of similar size and composition to compare with - but it does allow them to make comparisons more broadly too.) Anyway this is a presentational question, independent of the 'structural' question of how different sizes of household are corrected for in the calculation.

11.3 Children

There are two separate questions about how children are treated:

i. What proportion of adult environmental consumption needs do we assume children of different ages have - ie how do we correct for households of (say) 4 adults compared to 2 adults and 2 children?
ii. Who should be responsible for the environmental impacts of children?

Our preferred answer to the second question is that parents should be responsible for the environmental consumption of children up to 16. We proposed this in our paper to the first reference group meeting as a compromise between treating children as responsible for their own environmental impacts from birth, which would obscure the fact that choosing how many children to have is one of the biggest ways most people affect the environment, and making parents responsible for the 'life cycle' (literally 'cradle to grave') impacts of their children which would mean everyone was counted twice.

This answer would have the incidental merit of saving us having to answer the first question! This is because we would only count adult members of the household and attribute to them all the household's impacts including those caused by the children.

If this not agreed, we would suggest some 'rule of thumb' approximation like treating children under 5 as zero, those between 5 and 16 as .5 of an adult and everyone over 16 as 1. Given the huge variation between households in (for example) levels of extra purchasing, travel and space heating consequent on having children, we find it hard to see a way to be more precise.

11.4 Transition points

The extreme 'green' households are generally based on 'bottom up' answers for the greenest lifestyle which would strike most people as 'normal'. Of course it is *possible* to reduce these a lot further - we know people who have organised their affairs so as to live perfectly comfortably and happily with next to no use of fossil energy or mains services. But many people would regard this as loony, so quoting them would not help Going for Green's purpose. So we are aiming for (as it were) 'fifth percentile' rather than 'first percentile' behaviour - that is, what one household in twenty might do, rather than one in a hundred - although there are no figures to substantiate this statistically.

So for example on transport our greenest household does not have a car or ever travel by air - which after all is the behaviour of 40% of households in the UK (whether by choice or not). But they don't refuse to have anything to do with vehicles: they use buses and trains routinely, and taxis occasionally.

The lower and upper transitional points are generally based on assessment of how far people behaving in an 'averagely' environmentally careful or careless way would reduce or increase impacts from published household or individual mean values. For example in waste we posit the lower transitional household recycling about the half the volume of the recyclables which are most commonly and easily collected, ie paper and glass, and not making any significant waste reductions through active 'green purchasing' because there are actually very few opportunities for this if, like most people, you shop mostly at big supermarkets. The opportunities really start to come if you shop at wholefood co-ops, vegetable box schemes, furniture reclamation projects and so on - but we treat this as 'seriously green' behaviour below the lower transition point. The higher transitional household is based on not bothering to recycle anything and buying a higher proportion of disposables and things which are discarded unused.

We have argued against publishing an 'extremely wasteful' household. But we accept there is still a need to set the top of the red sector of the dial. This is in one sense a tougher problem than the lower end point because there is no upper limit to the amount of environmental consumption a household can achieve. (Sir James Goldsmith regularly flies to his Mexican hideaway in his personal Boeing 757 using 5000 gallons of fuel an hour - but King Fahd has a private 747 . . .) If this end point is set too low, many users will find themselves 'off the top of the scale' and unable to see their first improvements in impact rewarded by movement in the dials (although the scores will still change). But if it is set too high, any movement above the upper transition point will be squashed. This will be doubly demotivating: bad behaviour won't look so bad, but improvement action won't look so effective.

So we have attempted to define, as with the other limit, 'ninety-fifth' rather than 'ninety-ninth' percentile behaviour, ie flying round the world on holiday once a year (but in a scheduled plane!)

11.5 Units

In many cases (eg transport) the transitional household values need to be constructed from several different activities which are only unified via . . . the footprint! In these cases we have had to specify the households in terms of car kilometres *and* bus kilometres *and* , etc and leave it to the footprint algorithm to add these up. (Which is of course what it's for!)

11.6 From activities to footprints

The underlying logic is that households state their activities, the measure converts this into a footprint, and this is used to guide and motivate people to change their activities. 'If you change / reduce this activity, it will make X change in your footprint'. The comparison needs to be based on footprint. We therefore suggest adding a footprint figure to the facts wherever possible (although we have not been able to supply actual numbers since we don't have the algorithm model). We think we have picked on important effects. However this is a point which would benefit from iteration: if footprinting reveals any of them are in fact trivial, we would wish to change them.

11.7 Handy hints

We have tried wherever possible to echo or reinforce messages already being given out by responsible and credible organisations such as Friend of the Earth, the Energy Efficiency Office, Global Action Plan and Transport 2000: we are mindful of the point made forcefully by the consultees in phase 1 of this project that conflicting or inconsistent suggestions are worse than useless because they can be taken as an excuse to disregard the whole environmental message.

We have presented the hints in terms of change to activities. We suggest that for motivation they should be turned into 'what-ifs' in footprint terms. 'Suppose we reduced our [activity, eg 'car travel'] by x [activity unit, eg 'kilometres that the car travels each week], this would reduce the footprint by . . .' Obviously these numbers need to be calculated through the footprinting algorithm.

There are a few exceptions. For example we have presented the water figures in terms of cubic metres only for two reasons: a cubic metre of water is a more tangible, graspable thing than (say) a kilowatt-hour, and water has proved one of the dodgiest impacts to footprint!

12. TRANSPORT

12.1 Transition points

Units car km per week; for all others, household km per week (2.6 person household)

Green end: 2 taxi, 25 bus, 25 train, 80 bike
Green/amber 20 car (@40mpg), 50 bus, 50 rail, 5 air
Amber/red 400 car (@30mpg), 50 bus, 50 rail, 500 air
Red end - 800 car (@20mpg), 800 air

Basis

Green: Bottom - up lifestyle construction.

Amber/red: UK mean household car distance from government figures plus one long haul flight per person per year

Red end: globetrotter lifestyle

12.2 Facts

i. Each kilometre you fly uses XX times car (with 2 people) = XX times bus or train (Use footprint)

ii. Saving one 30km journey by an average car each week would save you XX

iii. The bus, train or plane would have been going anyway - so you may feel you shouldn't be responsible for their impacts at all. Or you might reason that your fare helps keep the service available for everyone. You might think this is a good thing for environmentally better options like bus and train, and a bad thing for environmentally worse options like flying!

iv. The only really green car is . . . a bicycle! Use one whenever you can. More than half the journeys in the UK are under 8km, which is ideal biking distance - does this apply to you?

12.3 Handy hints

[Where air > upper transition]

i. Holiday nearer home. One flight to Florida saves XX

[Where car > . . .]

ii. Drive more gently. Pretend there's an egg between your right foot and the accelerator pedal! It's easy to save 10% or more fuel this way - and wear and tear on the car (and you!)

iii. How do you think about your time? If a journey takes 3 hours by car but 4 hours by train - including getting to and from the station - do you count the rail journey as longer? Or shorter, because you have (perhaps) three hours in the middle to relax, read, work, eat or sleep instead of having to drive?

13. ENERGY

13.1 Transition points

Unit kwh primary energy per household (2.6) per year

Green end 11,270
Green/amber 16,905
Amber/red 22,540
Red end: 45,080

Basis

Government energy statistics household mean for amber / red
Broad targets of 20% / 25% / 30% reduction for green / amber. Sample green households for green end.

13.2 Facts

i. Home energy use is one of the biggest impacts most people have. Yours is about XX% of your total - so it's worth some attention.

ii. Gas only produces XX of the effect per unit of delivered energy as electricity. (Electricity could be as good if the industry built combined heat and power stations - where the waste heat is used too instead of being disposed of up cooling towers.)

13.3 Handy hints

i. [If electric > 2 x gas] Switching heating to gas could save XX of your impacts

ii. Just being more careful about turning off. 190 - 500kg [0 for below g/n transition, 190 - 500 between transitions, linear extrapolation above]

iii. Low-energy bulbs [can derive footprint savings for all these measures from KWh figures in EEO / GAP literature]

iv. Insulate cylinder and pipes

v. Draughtproofing

vi. Heating controls: programmer and room thermostat

vii. From 1998 onwards households will be able to choose who they buy electricity from. When rival suppliers ask for your custom, ask them what proportion of their generation comes from *renewable sources* such as wind, hydro, digestion of organic waste and 'energy crops' such as coppice wood. And ask them about the *mean thermal efficiency* of their coal and gas power stations. Prefer the suppliers who quote the highest numbers.

viii. If you are over 60, disabled or receiving household benefit, you may well be eligible for a grant for basic insulation and draughtproofing under the government's Homes Energy Efficiency Scheme (HEES). Contact [NEA]

14. WATER

14.1 Transition points

Unit Cubic metres per 3 person household per year

Green end 80
Green/amber 130

Amber/red 180
Red end 270

Source

Transitions interpolated between Thames Water 'low', 'medium' and 'high' consumption levels for 3-person households. 'Green' and 'red' ends extrapolated from these using 'bottom-up' lifestyle assumptions.

14.2 Facts

i. We think of Britain as a wet country. But much of England now has regular water shortages. Parts of West Yorkshire were without normal water supplies for months in the summer of 1996, and serious public health problems were only averted by 'importing' water in tanker lorries - at huge environmental as well as financial expense.

ii. Global warming is expected to make dry areas - the East and South East - drier. (But it's an unfair world. Areas that are already wet - Scotland, Wales, the West generally - are expected to get wetter still!)

iii. Water consumption has increased by 70% in some regions over the last 30 years. In 1993 the National Rivers Agency identified 40 areas in Britain where low flows in rivers were causing environmental problems.

14.3 Handy hints

i. A shower only uses 30 - 60 litres of water, a bath 50 - 170. Showering instead of bathing three times a week would save about 10 cubic metres a year per person. (Does not apply to power showers, which use as much as a bath.)

ii. Each run of a dishwasher uses 22 - 50 litres. Hand washing the same amount needs 10 litres or less. Using a dishwasher 4 times a week therefore takes 5 cubic metres a year more than hand washing.

iii. A hose uses 500 litres an hour - as much as 5 average baths, or 50 watering cans! Selectively watering the roots of the plants that really need it, instead of leaving a sprinkler on all evening, could save 1000 litres (or at least 0.5% of normal annual household consumption) each occasion.

iv. Kew Gardens recommend that even in the hottest weather lawns should not be watered more than twice a week. Watering too often can weaken growth and encourage roots to seek the surface where they dry up.

v. Fit a rainwater butt with a diverter valve (which diverts water from the rainwater pipe into the butt until it is full). Use the water on the garden and for outside washing.

15. WASTE

15.1 Transition points

Unit Tonnes of domestic waste per household (2.6) per year (including green waste but excluding appliances - covered in purchasing section)

Green end 0.31
Green/amber 0.7

Amber/red 0.86
Red end 1.4

Source

Upper transition based on national mean. Lower transition based on recycling about 50% of the common / easy materials: paper, glass, cans. Green end based on shopping carefully, reusing (eg milk bottles, soft drinks bottles, supermarket bags, washable nappies), home composting / digesting (eg Green Cone) all organic waste, recycling everything for which collection facilities generally exist. This achieves 10% reduction then 60% diversion, leaving only 36% of household average.

Red end: guesstimate 50% increase for careless / wasteful purchasing.

15.2 Facts

i. The average family throws away nearly a tonne [0.86 t] of waste a year.

ii. Landfills - the polite word for rubbish dumps - already cover . . . ha

iii. If we don't drastically reduce waste, London and the South East will run out of landfill space within 10 - 20 years.

iv. Follow the *waste hierarchy* - often called 'the four Rs'.

- Top preference is *reduce* - the best thing to do with rubbish is . . . not create it in the first place!
- Second, *reuse* - get two or three uses out of everything.
- Third - and only if you can't reduce or reuse - comes *recycling*.
- Fourth, *recover* secondary materials, for example by composting, digestion or incineration.

15.3 Handy hints

i. Don't accept extra layers of packaging you don't need in shops.

ii. Buy durable instead of disposable - razors, rechargeable batteries

iii. Buy goods in the largest convenient sizes: they usually have less packaging.

iv. Buy milk and soft drinks in refillable bottles, and generally reuse and refill whenever you can. Take supermarket bags back next time, use the back of paper for scrap.

v. If you have a baby, use cotton nappies. If you don't want the hassle of washing them yourself, there are nappy laundry services in many parts of the country. These will collect soiled nappies each week and leave you clean ones, washed in state - of - the - art hospital or commercial laundries. Contact National Association of Nappy Services, 0121 693 4949.

vi. Prefer types of container you can recycle locally - without making special car journeys to do it: these can easily undo the good of the recycling.

vii. Don't be fooled by labels saying 'recyclable'. Almost everything is recyclable in principle; the important question is whether, in your area, there is actually a scheme to collect and reprocess this material.

viii. If you have a garden, compost your vegetable scraps and garden waste. They are around 30% of most households' waste, and make an excellent fertiliser.

ix. Buy goods made from recycled products whenever you can, to create a market for them. (But remember that most of the cheapest 'economy' loo paper and kitchen paper has *always* been made from recycled paper - you can tell by the tiny speckles of ink left in it - you don't need to spend more on the 'designer' green brands!

APPENDIX A

ACTIVITY: TRANSPORT					Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
car	how many miles do you drive per year?		10000	miles						
	what is your average miles per gallon?		30	miles per gallon						
	do you have a catalytic converter? (1=yes)		0							
	estimated fuel use per year	FUEL	2438	litres	3.133406	0.021777	0.000000	0.023471	0.000000	0.000000
bus/coach	how many bus kilometres per year? (1 mile = 1.6093 km)	BUS	2500	km	0.069600	0.000722	0.000000	0.000463	0.000000	0.000000
train	how many train kilometres per year?	TRAIN	2500	km	0.114550	0.000865	0.000000	0.000548	0.000000	0.000000
air	how many air kilometres per year?	AIR	2500	km	0.261000	0.000497	0.000000	0.000406	0.000000	0.000000
	how many air trips? (take-offs)	TRIPS	4		0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL	total - transport	TOT_TRAN								

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares	hectares
0.000014	0.000496	1.2088
	0.000000	0.0000
0.000001	0.000011	0.0286
	0.000000	0.0000
0.000000	0.000018	0.0444
	0.000000	0.0000
0.000000	0.000040	0.0994
0.000056	0.000056	0.0002
		1.3815

ACTIVITY:	ENERGY				Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
gas	what is your annual gas consumption?	G	12000	kWh	0.203760	0.001266	0.000000	0.000072	0.000000	0.000000
electricity	what is your annual electricity consumption?	E	6000	kWh	0.832000	0.006955	0.000000	0.000692	0.017205	0.000000
coal	what is your annual coal consumption?	C	500	kg	4.948484	0.023000	0.000000	0.000000	0.000000	0.000000
heating oil	what is your annual heating oil use?	O	0	kg	3.858920	0.023000	0.000000	0.000000	0.000000	0.000000
bottled gas	how much bottled gas do you use per year?	LPG	0	litre	1.726623	0.000853	0.000000	0.000504	0.000000	0.000000
TOTAL	total - energy	TOT_EN								

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares	hectares
0.000000	0.000031	0.3740
	0.000000	0.0000
0.000000	0.000133	0.7963
	0.000000	0.0000
0.000000	0.000756	0.3778
	0.000000	0.0000
0.000000	0.000590	0.0000
	0.000000	0.0000
0.000000	0.000263	0.0000
		1.5481

ACTIVITY:	WATER				Activity to Impact Coefficients					
	(conversion of water resource impact to footprint should be set to zero in areas which are not drought-prone)				Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
water use	how many dishwasher cycles per week?	(40 litres)	3							
	how many clothes wash cycles per week?	(90 litres)	3							
	how many toilet flushes per day?	(9 litres)	6							
	how many baths per week?	(110 litres)	10							
	how many showers per week?	(30 litres)	10							
	how many hours of sprinkler/hose per year?	(1000 l/hr)	100							
	estimated water consumption:	WA	212.79	000 litres	0.457600				1.000000	

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares 0.000370	hectares **0.0786**

ACTIVITY: SHOPPING					Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
food	how do you spend per year on food?	FOOD	2500	£						
	(treat expenditure on meals out as food from UK)									
	(exclude home grown vegetables/fruit)									
	what percentage of the total value is on:									
	food from UK?	UK	40%		0.000591	0.000014	0.000015	0.000000	0.000000	0.000000
	food from Europe?	EUR	30%		0.054091	0.000651	0.000005	0.000110	0.000000	0.000001
	food by sea from rest of world?	SEA	20%		0.196591	0.002114	0.000004	0.000338	0.000000	0.000002
	food by air from rest of world?	AIR	10%		0.379591	0.012824	0.000004	0.003800	0.000000	0.000002
	(eg. fresh vegetables, flowers from tropical or Southern hemisphere countries)									
	unadjusted impact for food:									
	what percentage of the total value is on:									
	organic foods?	ORG	10%							
	meat or meat products?	MEAT	30%							
	adjusted impact for food:									
paper	how many newspapers do you buy a week?	NEWS	8	number	35.90733	0.223095		0.012685		0.008139
	(count each broadsheet as 1; each tabloid as 0.5; Sunday paper as 2)									
	how many disposable nappies per week?	NAPPY	0	number	3.141891	0.019521		0.001110		0.001047

cleaning	detergent (clothes or dishwashing machine)	DET	20	kg			0.062500			
	bleaches, limescale removers, chemicals	CHEM	2	kg						
			(trigger for health comments)							
appliances	do you own a fridge or fridge-freezer?		(trigger for health comments)							
	how many containing CFCs?	CFC	1		53.43					
	how many non-CFCs?	HCFC_HF	0		17.36					
hotels	how many room-nights did you spend in hotels last year (excluding business)?	HOTEL	10	room-night	32.2191	0.2404	0.0000	0.0203	1.3871	0.0000
	how many people per room (on average)?	PAX	2	guest-nights						
	what proportion of nights were luxury hotels?	LUX	50%							
TOTAL	grand total - purchasing	TOT_PUR								

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares	hectares
	0.000000	0.0000
	0.000000	0.0000
0.000000	0.000001	0.0006
0.000000	0.000010	0.0073
0.000000	0.000032	0.0160
0.000000	0.000062	0.0154
		0.0393
		-0.0004
		0.0078
	0.000000	0.0467
	0.013631	0.1091
	0.001528	0.0000

	0.000024	0.0005
	0.008121	0.0081
	0.002638	0.0000
0.0000	0.005351	0.0535
		0.2178

ACTIVITY:	HOUSE AND GARDEN				Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
embodied materials	what is the floor area of your home?	FLOOR	120	sq m	2.7100	0.0168	0.0000	0.0010	0.0000	0.0000
	if you do not live in a flat, indicate which type of house you live in (yes =1):									
	terraced house	TERR	1							
	semi-detached house	SEMI	0							
	detached house	DET	0							
	if new, does the house satisfy the Environmental Standard Award?	ESA	0	(1=yes, 0=no)						
house maint/ repair	how many UPCV/aluminium windows have you installed in last 30 years? (one window assumed to be approx 1.8m by 1.2 m)	ALUM_PL/	2	windows	218.3168	1.8250	0.0000	0.1817	4.5146	0.0000
	how many timber frame windows have you installed in this period?	TIMBER	2	windows	45.7045	0.3821	0.0000	0.0380	0.9451	0.0011
wood	did you buy any tropical hardwood last year? (trigger hints/tips re FSC)	HARD	0	cu m						2.2000
peat	how much peat did you use last year?	PEAT	100	litres						0.000520

chemicals	do you use garden chemicals?	CHEM_G	(trigger for health points)	
direct land use	how much private land does your house or block of flats occupy (including outbuildings, patios, driveways, green spaces and garden areas)	LAND	0.02	ha
	what share is attributable to your house?	SHARE	100%	
holidays	repeat above questions for holiday home, if appropriate			
TOTAL	grand total for buildings and land:	TOT_BL		

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares	hectares
0.0000	0.000415	0.0497
	0.000000	0.0000
0.0000	0.034826	0.0697
0.0000	0.008424	0.0168
	2.200000	0.0000
	0.000520	0.0520

	0.000000	0.0000
100%	1.000000	0.0200
	0.000000	0.0000
	0.000000	0.0000
	0.000000	0.0000
	0.000000	0.0000
	0.000000	0.0000
		0.2082

ACTIVITY:	WASTE				Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
rural?	do you live in a rural area (1=yes, 0=no)		0							
household waste	how many bags of waste do you dispose of each week (exclude anything which is reused,recycled, composted or burnt at home)		1.5	full black bags (12 kg)						
	estimated waste disposed of per year	WASTE	936	kg	0.364851	0.000017	0.000000	0.000000	0.000000	0.000000
	potential resource loss from total waste (without recycling/composting)	GROSS	1318	kg	0.959710	0.005963	0.000000	0.000339	0.000000	0.000176
recycling benefits	which of the following do you recycle regularly:			yes/no						
	glass bottles/jars	GLASS	1		-0.036310	-0.000226	0.000000	-0.000013	0.000000	0.000000
	paper	PAPER	0		-0.387959	-0.002410	0.000000	-0.000137	0.000000	-0.000176
	plastic bottles	PLASTIC	0		-0.177882	-0.001105	0.000000	-0.000063	0.000000	0.000000
	aluminium cans (eg. drink cans)	ALUM	0		-0.015649	-0.000097	0.000000	-0.000006	0.000000	0.000000
	steel cans (eg. food tins)	STEEL	0		-0.030156	-0.000187	0.000000	-0.000011	0.000000	0.000000
compostin(	do you compost your food/organic waste?	COMP	1							
liquid waste	what volumes, if any, of the following have you put down the drain in the past year?									

	engine oil	OIL	1	litres						0.022500
	pesticides/chemicals	PEST	1	(trigger for health comments)						
bulk disposals	what weight of inert waste have you disposed of in the past year?	BULK	0.5	tonnes	1.851000	0.017430	0.000000	0.000000	0.000000	0.000170
TOTAL	total-waste									

	Sum over impacts	Typical answer
Degraded/ Built-up Land	Footprint per unit	Footprint
1 hectare		
hectares	hectares	hectares
0.000000	0.000056	0.0523
0.000000	0.000323	0.4255
0.000000	-0.000006	-0.0073
0.000000	-0.000235	0.0000
0.000000	-0.000027	0.0000
0.000000	-0.000002	0.0000
0.000000	-0.000005	0.0000

	0.022500	0.0225
0.000000	0.000454	0.0002
		0.4932

ACTIVITY:	VOLUNTARY ACTION				Activity to Impact Coefficients					
					Global Warming Potential	Acid-ification	Eutroph-ication	Summer Smog	Water Resource Depletion	Biomass/ Biodiversit
		Translation to footprint/health points			0.000152 ha per kg	0.00015 ha per kg	0.00038 ha per kg	0.000075 ha per kg	0.0003 ha per kl	1 hectare
Activity	Question	Answer	Typical Answer	Units:	kg CO2 equivalent	kg SO2 equivalent	kg P equivalent	kg PCOP equivalent	000 litres water	hectares
	In the last year:									
volunteer days	how many days did you spend on voluntary action related to the environment?	VOL	10	days	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	total - volunteer days									

	Sum over impacts	Typical answer	Volunteer days
Degraded/ Built-up Land	Footprint	Footprint	Days
1 hectare			
hectares 0	hectares 0.000000	hectares 0.0000	10.00 10.00

SUMMARY OF TYPICAL IMPACTS:

ACTIVITY:		footprint (ha)	volunteer days
	transport	1.38	
	energy	1.55	
	water	0.08	
	purchasing	0.22	
	buildings/land	0.21	
	waste	0.49	
	voluntary activities		10.00
	grand total:	3.93	10.00

APPENDIX B

TOPIC: TRANSPORT (1)

QUESTION: ESTIMATED FUEL USE PER YEAR (FUEL : units litres) (CAT : 1 if catalytic converter; 0 otherwise)

ENVIRONMENTAL IMPACT	Equation	Coefficients (from Transport : 2.1 - 2.5) 2.8827
Global Warming Potential (kg CO2 equiv)	FUEL × 2.8827 ~~0.7862~~ × 1000 × 1.45 / 1334	~~0.7862~~ = CAR_CO2 (tonnes CO2 per tonne fuel) 1.45 = UPLIFT (uplift for energy in car/road etc) 1334 = CONV_L_T (conversion: litres per tonne) ~~1000 = conversion tonnes - kg~~
Acidification (kg SO2 equiv)	FUEL × 0,02905 × (1 - CAT × 0.5) × 1000/1334	0.02405 = CAR-SO2 (tonnes SO2 equiv. per tonne fuel) 1334 = CONV_L_T 0.5 = CAT_SAVE (emissions saving with cat. converter)
Eutrophication	0	
Summer Smog (kg PCOP equiv)	FUEL × 0.03131 × (1 - CAT × 0.5) × 1000/1334	0.03131 = CAR_SS (tonnes PCOP equivalent per tonne fuel) 0.5 = CAT_SAVE 1334 = CONV_L_T
Water Resource Depletion ('000 litres)	0	
Bio-diversity Land (ha)	0	
Degraded Land (ha)	FUEL × 805375 × 0.6/(25057800 × 1334)	805,375 = ROAD_LAND (ha) 0.6 = CAR_LAND% (%) 25,057,800 = CAR - TOT ~~FUEL~~ (tonnes) 1334 (as above)

TOPIC: TRANSPORT (2)

QUESTION: ESTIMATED BUS KM PER YEAR (UNITS: pass km)

ENVIRONMENTAL IMPACT	Equation	Coefficients (from Transport 3.1 – 3.5)
Global Warming Potential	0.048 × 1.45 × BUS	0.048 = BUS_CO2 (kg CO_2 per passenger km) 1.45 = UPLIFT (see above)
Acidification	BUS × 1000 × (3780 + 0.7 × 42030) / 46,000,000,000	3780 = BUS_SO2 (tonnes – total) 42030 = BUS_NOX (tonnes – total) 0.7 = CONV_NOx (convert NOx to SO_2 equiv) 46,000,000,000 = BUS_TOT (pass-km, total) 1000 = conversion tonnes-kg
Eutrophication	0	—
Summer Smog	BUS × 1000 × (42030 + 11480) × 0.398 / 46,000,000,000	42030 = (as above) BUS_NOX 11480 = BUS_VOC (tonnes – total) 0.398 = CONV_PCOP (convert VOC, NOx to PCOP) 46,000,000,000 = BUS_TOT (as above) 1000 = conversion tonnes-kg
Water Resource Depletion		—
Bio-diversity Land		—
Degraded Land	BUS × 805 375 × 0.04 / 46,000,000,000	805,375 = ROAD_LAND (as for Car) 0.04 = BUS_LAND% (%) 46,000,000,000 = BUS_TOT (as above)

TOPIC: TRANSPORT (3)

QUESTION: ESTIMATED TRAIN KILOMETRES PER YEAR (UNITS: km)

ENVIRONMENTAL IMPACT	Equation	Coefficients (from Transport 4.1 – 4.5)
Global Warming Potential	TRAIN x 0.079 x 1.45	0.079 = TRAIN_CO2 (kg CO2 per passenger km) 1.45 = UPLIFT (as for car)
Acidification	TRAIN x 1000 x (3000 + 0.7 x 37000)/33,400,000,000	3000 = TRAIN_SO2 (tonnes - total) 37000 = TRAIN_NOx (tonnes - total) 0.7 = CONV_NOx (as elsewhere) 33,400,000,000 = TRAIN_TOT (pass-km - total) 1000 = conversion tonnes-kg
Eutrophication	0	
Summer Smog	TRAIN x 1000 x (37000 + 9000) x 0.398/33,400,000,000	37,000 = TRAIN_NOx (as above) 9,000 = TRAIN_VOC (tonnes - total) 0.398 = CONV_PCOP (as above) 33,400,000,000 = TRAINS_TOT (~~pass~~ as above)
Water Resource Depletion		
Bio-diversity Land		
Degraded Land	TRAIN x (2481 + (16585 x 0.3)) x 0.8 / 33400,000000	2481 = STATION_LAND (ha) 16585 = TRACK (km) 0.3 = WIDTH (ha per km) 0.8 = PASS_LAND (%) 33,400,000,000 = TRAINS_TOT (as above)

TOPIC: TRANSPORT (4a)

QUESTION: HOW MANY AIR KILOMETRES PER YEAR (Units : km) [see also TRIPS]

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0.18 × 1.45 × AIR	0.180 = AIR_CO2 (kg CO2 per pass km) 1.45 = UPLIFT (as above)
Acidification	AIR × 0.7 × 0.0071	0.7 = CONV_NOx (as above) 0.0071 = AIR-NOx (kg NOx per pass km)
Eutrophication	0	/
Summer Smog	AIR × 0.398 × (0.0071 + 0.0031)	0.398 = CONV- PCOP (as above) 0.00 71 = AIR- NOx (as above) 0.0031 = AIR-VOC (kg VOC per pass km)
Water Resource Depletion	0	/
Bio-diversity Land	0	/
Degraded Land	0	/

TOPIC: TRANSPORT 4(b)

QUESTION: HOW MANY AIR TRIPS PER YEAR? (Units : number of take-off/landing cycles)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	(Remain zero)
Acidification	0	" " "
Eutrophication	0	
Summer Smog	0	" " "
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	TRIPS × 8361 × 0.5/75,000,000	8361 = AIR_LAND (ha) 0.5 = PASS_AIR% (% land attributable to pass. traffic) 75,000,00 = AIR_TOT (total pass. journeys - UK airlines)

TOPIC: ENERGY (1)

QUESTION: ANNUAL GAS CONSUMPTION (G - Units: kWh)

ENVIRONMENTAL IMPACT	Equation	Coefficients Energy
Global Warming Potential	$G \times (0.198 + 0.00576)$	0.198 = GAS_CO2 (kg per kWh) 0.00576 = GAS_METH (kg of CO_2 equiv per kWh)
Acidification	GAS_AC $G \times \frac{(0.7 \times 142000 \times 1000 \times 0.42)}{32.97\,68{,}65{,}0000}$	0.7 = CONV_NOX (as above) 142,000 = GAS_NOX (tonnes, total) 0.42 = DOM_GAS% (% domestic sector) 329,768,650,000 = GAS_TOT (dom sector consumption, tonnes)
Eutrophication	0	
Summer Smog	GAS_CC $G \times \frac{(0.398 \times 142000 \times 0.42 \times 1000)}{32\,9{,}76\,8{,}650{,}000}$	0.398 = CONV_PCOP & (other coefficients as above)
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: (ENERGY (2)

QUESTION: ANNUAL ELECTRICITY CONSUMPTION (E - Units: kWh)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$E \times 0.832$	0.832 = ELEC_CO2 (kg per kWh)
Acidification (kg SO_2 equivalent)	$E \times \underbrace{\frac{(1{,}759.000 + 0.7 \times 526{,}000) \times 1000}{305{,}850{,}000{,}000}}_{\text{ELEC-AC}}$	0.7 = CONV_NOX (as above) (1000 = conversion tonnes-kg 1,759,000 = ELEC-SO2 (tonnes, total) 526,000 = ELEC_NOX (tonnes, total) 305,850,000,000 = ELEC-TOT (elec supplied, kWh, total)
Eutrophication		
Summer Smog	$E \times \underbrace{\frac{0.398 \times (526{,}000 + 6{,}000) \times 1000}{305{,}850{,}000{,}000}}_{\text{ELEC\_SS}}$	0.398 = CONV_PCOP (as above) 526,000 = ELEC-NOx (tonnes, total) (as above) 6,000 = ELEC-VOC (tonnes, total) 305,850,000,000 = ELEC-TOT (as above)
Water Resource Depletion ('000 litres)	$E \times \underbrace{\frac{12{,}612{,}000 \times 365}{(314{,}780{,}000{,}000 \times 0.85)}}_{\text{ELEC\_W}}$	12,612,000 = ELEC-WAT ('000 litres per day) 365 = DAYS (in year) 314,780,000,000 = ELEC-TOT95 (kWh) 0.85 = ELEC_ENGW% (% generated in England & Wales)
Bio-diversity Land		
Degraded Land		

TOPIC: ENERGY (3)

QUESTION: ANNUAL COAL CONSUMPTION (C - Units: kg)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$C \times 0.586 \times 30.4 \times 277.78/1000$	0.586 = COAL_CO2 (kg per kWh) 30.4 = COAL_GJ (GJ per tonne conversion) 277.78 = CONV_GJ_KWH (kWh per GJ conversion) 1000 = conversion tonnes-kg
Acidification	$C \times 0.023$	0.023 = COAL_SO2 (tonnes SO_2 per tonne coal) or equivalently (kg SO_2 per kg coal)
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: ENERGY (4)

QUESTION: ANNUAL HEATING OIL USE (O - Units: kg)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	"O" * 0.302 * 46 * 277.78/1000	0.302 = OIL_CO2 (kg per kWh) 46 = OIL_GJ (GJ per tonne conversion) 277.78 = CONV_GJ_KWH (as above) 1000 = conversion tonnes - kg
Acidification	O * 0.023	(as for coal)
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: ENERGY (5)

QUESTION: ANNUAL USE OF BOTTLED GAS (LPG) (UNITS: LITRES)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential (kg CO_2 equiv)	LPG × (LPG_GWP)	(LPG_GWP) $= \frac{1.874 \times 3.667}{3.98}$ where carbon emissions = 1874 g /therm 1 therm = 3.98 litres and 1 kg carbon = 3.667 kg CO_2
Acidification (kg SO_2 equiv)	LPG × (LPG_AC)	(LPG_AC) $= \frac{0.00485 \times 0.7}{3.98}$ where NO_x emissions = 4.85 g/therm 1 therm = 3.98 litres LPG CONV_NOX = 0.7
Eutrophication	0	
Summer Smog (kg PCOP equiv)	LPG × (LPG_SS)	(LPG_SS) = 0.398 × (0.00485 + 0.000 19 [illegible]) / 3.98 where NO_x emissions = 4.85 g/therm VOC emissions = 0.194 g/therm CONV_PCOP = 0.398 1 therm = 3.98 litres LPG
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: WATER USE (1)

QUESTION: ESTIMATED WATER CONSUMPTION (WA : Units '000 litres per year)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	WA * 0.55 * 0.832	0.55 = WAT_ELEC (kWh per 1,000 litres water supplied) 0.832 = ELEC_CO2 (as above ; kg CO_2 per kWh)
Acidification		
Eutrophication		
Summer Smog		
Water Resource Depletion	WA * 1.0	direct conversion: (1,000 litres water translates directly into 1,000 litres water resource depletion)
Bio-diversity Land		
Degraded Land		

UNITS:
(kg)

TOPIC: WASTE (1) - COLLECTION & DISPOSAL

QUESTION: HOW MUCH WASTE DO YOU DISPOSE OF PER YEAR (excluding anything recycled, composted or burnt at home?)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$WASTE \times \left(\frac{1851 \times (1-RUR) + 15914 \times RUR + 33000 \times 11}{1,000,000}\right)$	RUR = 1 if rural; 0 if urban 1851 = ~~WAS~~ CO2-URB (g/tonne) 15914 = CO2-RUR (g/tonne) 33000 = METH-WAS (g/tonne) (1,000,000 = conversion from (g/tonne) to (kg per kg))
Acidification	$WASTE \times \underbrace{\boxed{\left(\frac{24.9 \times (1-RUR) + 307.3 \times RUR}{1,000,000}\right)} \times 0.7}_{WAS\_AC}$	24.9 = SO_2-URB (g/tonne) 307.3 = SO2-RUR (g/tonne) 0.7 = CONV-NOX } other factors as above
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	$WASTE \times \boxed{\frac{0.0000025 \times 100}{1000}}$ — WAS_LAND	LAND_WAS = 0.0000025 ha/tonne LIFE-DEG-LAND = 100 years (conversion: tonnes → kg)
Degraded Land	0	

X

TOPIC: WASTE (2) – RESOURCE LOSS

QUESTION: DO YOU RECYCLE/COMPOST ANY OF THE FOLLOWING?

- glass
- paper
- plastic
- aluminium cans
- steel cans
- food waste

(UNITS : yes/no)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$\frac{WASTE}{(GROSS\_UP)} \times \overbrace{\{P_g \times E_g + P_p \times E_p + P_{pl} \times E_{pl} + P_a \times E_a + P_s \times E_s\}}^{LOSS\_KWH} \times (GAS\_CO2 + GAS\_METH)$	$GROSS\_UP = (1 - R_g \times P_g - R_p \times P_p - R_{pl} \times P_{pl} - R_a \times P_a - R_s \times P_s - COMP \times P_{comp})$
Acidification	$\frac{WASTE}{(GROSS\_UP)} \times (LOSS\_KWH) \times GAS\_AC$	where R_g = 1 if glass recycled, no otherwise R_p = 1 " paper " " " R_{pl} = 1 " plastics " " "
Eutrophication	0	R_a = 1 " alum. " " " R_s = 1 " steel cans " " " $COMP$ = 1 if food waste composted " "
Summer Smog	$\frac{WASTE}{(GROSS\_UP)} \times (LOSS\_KWH) \times GAS\_SS$	and P_g = 9% (typical proportion of glass in hh was P_p = 16% (" " " recyclable paper " " "
Water Resource Depletion	0	P_{pl} = 2% (" " " " plastic " " ") P_a = 0.4% (" " " " alum. " " ") P_s = 5% (" " " " steel " " ")
Bio-diversity Land	$\frac{WASTE}{(GROSS\_UP)} \times (P_p \times L_p)$	P_{comp} = 20% (" " " putrescibles " " " and E_g = 9 kWh/kg (energy embodied in glass)
Degraded Land	0	E_p = 16,9 kWh/kg (" " " paper) E_{pl} = 45 kWh/kg (" " " plastic) E_a = 20 kWh/kg (" " " alum.)

E_s = 4 kWh/kg (" " steel)

and L_p = 0.0011 hectares/kg

TOPIC: WASTE (3) – RECYCLING BENEFITS

QUESTION: DO YOU RECYCLE . . . . (continued)

ENVIRONMENTAL IMPACT	Equation GLASS	PAPER	PLASTIC	~~Coefficients~~ ALUMINIUM	STEEL	COMPOSTING
Global Warming Potential	$-\frac{\text{WASTE}}{(\text{GROSS\_UP})}\left(R_{g} P_{g} \times E_{gj}\right) \times \sum_{ij} (\text{GAS\_GW})$	as for glass: $(R_p \times P_p \times E_{pj}) \sum_{p}$	as for glass $(R_{pl} \times P_{pl} \times E_{plj}) \sum_{pl}$	as for glass $(R_a \times P_a \times E_{aj}) \sum_{a}$	as for glass: $(R_s \times P_s \times E_{sj}) \times \sum_{s}$	no ↑ direct
Acidification	$-\frac{\text{WASTE}}{(\text{GROSS\_UP})}\left(R_{g} \times P_{g} \times E_{gj}\right) \times \sum_{ij} (\text{GAS\_AC})$	"	"	"	"	benefit
Eutrophication	0	0	0	0	0	↓
Summer Smog	$-\frac{\text{WASTE}}{(\text{GROSS\_UP})}\left(R_{g} P_{g} \times E_{gj}\right) \times \sum_{ij} (\text{GAS\_SS})$	"	"	"	"	
Water Resource Depletion	0	0	0	0	0	
Bio-diversity Land	0	$-\frac{\text{WASTE}}{(\text{GROSS\_UP})}\left(R_{p} \times P_{p} \times L_{p}\right)$				
Degraded Land	0					

(NOTE: if all elements recycled, benefit should ~~equal~~ sum to 'potential resource loss')

TOPIC: WASTE (4) -

QUESTION: WHAT VOLUME, IF ANY, OF ENGINE OIL HAVE YOU POURED DOWN THE DRAIN IN THE PAST YEAR (UNITS: litres)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	
Acidification	0	
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	OIL x 0.022500	BIO_OIL = 0.022500 ha/litre
Degraded Land	0	

TOPIC: WASTE (5)

QUESTION: WHAT WEIGHT OF INERT/BULK WASTE HAVE YOU DISPOSED OF IN THE PAST YEAR (IN ADDITION TO NORMAL COLLECTIONS)?

(UNITS: tonnes)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	BULK × (1857 × (1-RUR) ~~×~~ + 15914 × RUR)/1000	1551 = CO2-URB (g/tonne) 15914 = CO2-RUR (g/tonne) 1000 = conversion (g → kg) of CO2
Acidification	BULK × (WAS_AC) × 1000	(WAS_AC as qn ①) 1000 = conversion (kg → tonnes)
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	BULK × ~~(WAS-LAND) × 1000~~ BULK-LAND	~~(WAS-LAND as qn ①)~~ ~~1000 = conversion (kg→tonnes)~~ BULK-LAND = 0.00017 (ha/tonne)
Bio-diversity Land	0 BULK × BULK-LAND BULK = 0.00017	BULK-LAND = 0.00017 (ha/tonne)
Degraded Land	0	

TOPIC: SHOPPING (1)

QUESTION: HOW MUCH SPENT ON FOOD FROM UK $(£/_{yr})$? (FOOD × UK% × ADJ)

ENVIRONMENTAL IMPACT	Equation	Coefficients UK% = percentage expenditure on UK-source food
Global Warming Potential	FOOD × UK% × ADJ × 0.000591	UK_GWP = 0.000591 where ADJ = (1 − 0.1 × ORG + 0.66 × MEAT.) ORG: = percentage organic; MEAT = percentage meat products
Acidification	FOOD × UK% × ADJ × 0.000014	UK_AC = 0.000014
Eutrophication	FOOD × UK% × ADJ × 0.0000146	UK-EUT = 0.0000146
Summer Smog	FOOD × UK% × ADJ × 0.0000000	UK_SS = 0.0000008/1000
Water Resource Depletion	0	
Bio-diversity Land	FOOD × UK × ADJ × 0.00000046	UK-LAND = 0.0004647/1000
Degraded Land	0	

TOPIC: SHOPPING (2)

QUESTION: HOW MUCH SPENT ON FOOD FROM EUROPE (£/yr)? (FOOD × EUR% × ADJ)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	FOOD × EUR% × ADJ × 0.054091	EUR_GWP = 0.054091
Acidification	FOOD × EUR% × ADJ × 0.000651	EUR_AC = 0.000651
Eutrophication	FOOD × EUR% × ADJ × 0.000005	EUR_EUT = 0.000005
Summer Smog	FOOD × EUR% × ADJ × 0.000110	EUR_SS = 0.000110
Water Resource Depletion	0	
Bio-diversity Land	FOOD × EUR% × ADJ × 0.000001	EUR_LAND = $\frac{0.0004647 \times 3140}{10780 \times 1000}$
Degraded Land	0	

TOPIC: SHOPPING (3) (FOOD × SEA% × ADJ)

QUESTION: HOW MUCH SPENT ON FOOD TRANSPORTED BY SEA FROM REST OF WORLD (£/yr)?

ENVIRONMENTAL IMPACT	Equation	Coefficients SEA - GWP = 0.196591
Global Warming Potential	FOOD × SEA × ADJ × 0.196591	SEA = percentage expenditure on food transported by sea from rest of world
Acidification	FOOD × SEA × ADJ × 0.002114	SEA - AC = 0.002114
Eutrophication	FOOD × SEA × ADJ × 0.0000037	SEA_EUT = 0.0000037
Summer Smog	FOOD × SEA × ADJ × 0.000338	SEA_SS = 0.000338
Water Resource Depletion	0	
Bio-diversity Land	FOOD × SEA × ADJ × 0.000002	Bi COW_LAND: $\frac{0.0004647 \times 31400}{7990 \times 1000}$
Degraded Land	0	

TOPIC: SHOPPING (4)

(FOOD x AIR x ADJ)

QUESTION: HOW MUCH SPENT OF FOOD TRANSPORTED BY AIR FROM REST OF WORLD (£/yr)?

ENVIRONMENTAL IMPACT	Equation	Coefficients AIR-GWP = 0.379591
Global Warming Potential	FOOD x AIR x ADJ x 0.379591	AIR = percentage expenditure on food transported by air from rest of world
Acidification	FOOD x AIR x ADJ x 0.012824	(eg. fresh vegetables & flowers) AIR - AC = 0.012824
Eutrophication	FOOD x AIR x ADJ x 0.0000037	AIR - ~~AC~~ EUT = 0.0000037
Summer Smog	FOOD x AIR x ADJ x 0.000338	AIR -SS = 0.000338
Water Resource Depletion	0	0
Bio-diversity Land	FOOD x AIR x ADJ x 0.00002	ROW-LAND (as above)
Degraded Land	0	0

TOPIC: SHOPPING (5)

QUESTION: HOW MANY NEWSPAPERS DO YOU BUY A WEEK? (UNITS: number)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential kg CO_2 equiv.	$\text{NEWS} \times \overbrace{\boxed{(52 \times 0.2) \times \left(\frac{61 \times 277.78}{1000}\right)}}^{\text{NEWS\_KWH}} \times (\text{GAS\_CO2} + \text{GAS\_METH})$	52 = weeks per year 0.2 = NEWS_ ~~GRAM~~ KG 1000 = MJ per GJ 61 = PAPER_ENERGY (MJ/KG) 277.78 = CONV_GJ_KWH
Acidification	NEWS × (NEWS_KWH) × GAS_AC	
Eutrophication	0	
Summer Smog	NEWS × (NEWS_KWH) × GAS_SS	
Water Resource Depletion	0	
Bio-diversity Land	$\text{NEWS} \times \left(\frac{52 \times 0.2}{1000}\right) \times \frac{1.8}{2.3}$	52 = weeks per year 0.2 = NEWS_KG 1.8 = NEW_FIBRE (m^3/tonne) 2.3 = PAPERYIELD (m^3/ha/year) 1000 = kg per tonne
Degraded Land	0	

TOPIC: SHOPPING (6)

QUESTION: HOW MANY DISPOSABLE NAPPIES DO YOU BUY A WEEK?) (UNITS: number)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$NAPPY \times \overbrace{52 \times 0.035 \times 50\% \times \left(\frac{61 \times 277.78}{1000}\right)}^{NAPPY\_KWH} \times (GAS\_CO2 + GAS\_METH)$	52 = weeks per year 0.035 = NAPPY_KG 50% = NAPPY_% PAPER 61 = PAPER_ENERGY (MJ/KG) 277.78 = CONV_GJ_KWH
Acidification	$NAPPY \times (NAPPY\_KWH) \times GAS\_AC$	
Eutrophication	0	
Summer Smog	$NAPPY \times (NAPPY\_KWH) \times GAS\_SS$	
Water Resource Depletion	0	
Bio-diversity Land	$NAPPY \times \left(\frac{52 \times 0.035 \times 50\%}{1000}\right) \times \frac{1.8}{2.3} \times \frac{1}{(1-0.32)}$	52 = weeks per year 0.035 = NAPPY_KG 50% = NAPPY_% PAPER 1000 => kg / tonne 1.8 = NEW_FIBRE (m3/tonne) 2.3 = PAPER_YIELD (m3/ha/year) (1-0.32) = NOT_REC (adjust for fact that most paper contains approx 32 % recycled fibre but nappies do not)
Degraded Land	0	

TOPIC: SHOPPING (7) (UNITS: kg / year)

QUESTION: HOW MANY KILOGRAMMES OF CLOTHES OR DISHWASHING DETERGENT DO YOU BUY PER YEAR?

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	
Acidification	0	
Eutrophication	DET $\times$ 0.0625	DET-EUT = 0.0625 (kg phosphate equiv. per kg)
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: SHOPPING (8)

QUESTION: HOW MANY FRIDGE-FREEZERS CONTAINING HFCS/HCFCS DO YOU OWN? (HCFC_HFC)
HOW MANY FRIDGE-FREEZERS CONTAINING CFCS DO YOU OWN? (CFC)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	CFC × (748/14) + HCFC–HFC × (243/14)	748 = INSUL_CFC 243 = INSUL_HCFC
Acidification		14 = LIFE_FRIDGE
Eutrophication		If not safely disposed of, add: 426 = COOLANT_CFC
Summer Smog		168 = COOLANT_HFC
Water Resource Depletion		
Bio-diversity Land		
Degraded Land		

TOPIC: SHOPPING (9) - HOTEL ACCOMMODATION

QUESTION: HOW MANY PEOPLE PER ROOM (ON AVERAGE)
HOW MANY HOTEL NIGHTS PER YEAR?
WHAT PROPORTION IN LUXURY HOTELS?

UNITS: PAX (number/room)
NIGHTS (number)
LUX (%)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	= HOTEL × {53 × (GAS_CO2 + GAS_METH) + 18 × (ELEC_CO2)} × (1 + LUX × 0.5)	53 = HOTEL_GAS (kwh per night) 18 = HOTEL_ELEC (kWh per night) 0.5 = LUX_UPLIFT
Acidification	= HOTEL × (53 × GAS_AC + 18 × ELEC_AC) × (1 + LUX × 0.5)	where GAS_AC = total coefficient for acidification from gas ELEC_AC = " " " " from elec.
Eutrophication	0	
Summer Smog	= HOTEL × (53 × GAS_SS + 18 × ELEC_SS) × (1 + LUX × 0.5)	where GAS_SS = total coefficient for s.smog from gas ELEC_AC = " " " " " elec
Water Resource Depletion	= HOTEL × (18 × ELEC_WAT + 0.4 × PAX) × (1 + LUX × 0.5)	where ELEC_W = coefficient for water use by elec. gen 0.4 = PAX_WATER ('000 litres per guest night)
Bio-diversity Land	0	
Degraded Land	0	

TOPIC: HOUSE & ~~GARDEN (1)~~ – EMBODIED ENERGY

QUESTION: IF NEW, DOES HOUSE MEET ENV STANDARD AWARD?
WHAT IS THE FLOOR AREA OF YOUR HOME?
DO YOU LIVE IN A FLAT / TERRACED HOUSE / SEMI OR DETACHED HOUSE?

- ESA (yes/no)
- FLOOR – m^2
- TERR – (yes/no) etc

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	$\text{FLOOR} \times \text{FORM} \times 10 \times (1 - 0.7 \times \text{ESA}) \times (\text{GAS-CO2} + \text{GAS-METH})$	$\text{FORM} = (1 + 0.33 \times \text{TERR} + 0.67 \times \text{SEMI} + 1.0 \times \text{DET})$ $0.7 = \text{ESA-SAVING}$ $10 = \text{FLOOR-KWH}$ (energy .. .. .. per m^2)
Acidification	$\text{FLOOR} \times \text{FORM} \times 10 \times (1 - 0.7 \times \text{ESA}) \times (\text{GAS-AC})$	FORM as above ESA-SAVING " FLOOR-KWH "
Eutrophication	0	
Summer Smog	$\text{FLOOR} \times \text{FORM} \times 10 \times (1 - 0.7 \times \text{ESA}) \times (\text{GAS-SS})$	(as above)
Water Resource Depletion	0	
Bio-diversity Land	0 6	
Degraded Land		

in ALUM/ PLASTIC
OR TIMBER

TOPIC: HOUSE & GARDEN (2)

QUESTION: HOW MANY WINDOWS HAVE YOU REPLACED OR ADDED IN LAST 30 YEARS ? (ONE WINDOW EQUIVALENT TO APPROX SIZE 1.8m × 1.2m)

(UNITS:
ALUM-PLAS - num
TIMBER - num

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	ALUM ~~*~~_PLAS × (7872/30) × ELEC-CO2 or TIMBER × {(1024 + (6×104))/30} × ELEC-CO2	7872 = UPVC-KWH 1024 = TIMB_KWH 104 = PAINT_KWH 30 = LIFE 6 = PAINT_FREQ
Acidification	ALUM-PLAS × (7872/30) × ELEC-AC or TIMBER × ((1024 + (6×104))/30) × ELEC-AC	(as above)
Eutrophication	0	
Summer Smog	ALUM_PLAS × (7872/30) × ELEC-SS or TIMBER × (1024 + (6×104)/30) × ELEC-SS	(as above)
Water Resource Depletion	ALUM-PLAS × (7872/30) × ELEC-W or TIMBER × (1024 × (6×104)/30) × ELEC.W	(as above)
Bio-diversity Land	0 or TIMBER × $\frac{100}{1000}$ × $\frac{0.34}{30}$ × 1 ~~0.44~~	~~0.44~~ 0.34 = TIMB-HA (hectares forest per m3) 1 = TIMB_M3 (estimate m3 per tonne) 100 = WINDOW-KG (estimate weight of timber frame) 1000 = CONVERSION kg → tonne 30 = LIFE
Degraded Land	0	

TOPIC: HOUSE & GARDEN (3)

QUESTION: DID YOU BUY ANY ~~NON FSC~~ TROPICAL HARDWOOD LAST YEAR? (UNITS: m3)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	
Acidification	0	
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	HARD * ~~0.50~~ 2.2	HARD_YIELD = ~~0.50~~ 2.20 m³/hectare/year
Degraded Land		

TOPIC: HOUSE & GARDEN (4)

QUESTION: HOW MUCH PEAT, IF ANY, DID YOU USE LAST YEAR? (UNITS: litres)

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	
Acidification	0	
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	PEAT × 0.00052	PEAT_LAND = 0.00052 ha/litre
Degraded Land		

no footprint effect

- trigger health points

TOPIC: HOUSE & GARDEN (5)

QUESTION: DO YOU USE ANY GARDEN CHEMICALS?

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential		
Acidification		
Eutrophication		
Summer Smog		
Water Resource Depletion		
Bio-diversity Land		
Degraded Land		

TOPIC: HOUSE & GARDEN (6)

QUESTION: HOW MUCH LAND DOES YOUR HOUSE OR FLAT OCCUPY? (UNITS : HECTARES)
WHAT IS YOUR SHARE OF THIS?

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	0	
Acidification	0	
Eutrophication	0	
Summer Smog	0	
Water Resource Depletion	0	
Bio-diversity Land	LAND × SHARE	(within LAND, include outbuildings, patios, driveways, gardens & green spaces)
Degraded Land		

TOPIC: VOLUNTARY ACTIONS (1)

QUESTION: HOW MANY DAYS HAVE YOU SPENT ON ENVIRONMENTAL VOLUNTARY WORK IN THE PAST YEAR? (DA

ENVIRONMENTAL IMPACT	Equation	Coefficients
Global Warming Potential	no footprint	
Acidification		
Eutrophication		
Summer Smog		
Water Resource Depletion		
Bio-diversity Land		
Degraded Land		

DAYS counted directly and converted to 'green smiley faces' on screen.

APPENDIX C

APPENDIX C: DISCUSSION OF POSSIBLE MEASURES OF HEALTH AND LOCAL ENVIRONMENTAL QUALITY

This appendix discusses possible methodologies for deriving common measures of health and local environmental quality, and combining these with ecological footprints into a single 'eco-calorie' measure. While these methodologies were not felt to be sufficiently robust or workable to justify inclusion in the eco-calorie at this stage, they are presented here to document our thinking process in this study and provide a starting point for any further work on these issues.

1. HEALTH EFFECTS

The discussion below focuses on two main types of health issues:

- environmental pollutants (eg. ozone layer depletion, winter smog, pesticides, heavy metals, carcinogens)
- health and safety.

1.1 Environmental pollutants

Sources:
Valuation of Environmental Externalities, Department of Transport 1995
Climate Change, Acidification and Ozone - Potential Impacts on the English Countryside, Countryside Commission, 1995
Air Pollution and Daily Mortality in London 1987-92, British Medical Journal Vol 312, 1996
The Eco-indicator 95, Netherlands Agency for Energy and the Environment

Any attempt to identify the health effects of pollutants and other environmental damage runs into very similar problems as for air pollutants discussed under acidification in Chapter 3 of the main report. Thus:

- there is no straight forward link between emissions and ambient concentrations
- the impact on humans of ambient concentrations depends on whether those concentrations have reached critical loads (often described as toxic levels for human health)
- the impact depends on the kind of person who experiences the pollution, eg. age and general health are important factors
- studies of the impact on health of ambient concentrations, levels of stratospheric ozone depletion, and noise have mainly been concerned to demonstrate that there is some impact on health (eg. more skin cancers, more attacks of bronchitis), but there has been no attempt to measure this in terms of quality years. Even impact on life expectancy is not available. Studies of the impact of air pollutants consider increases in mortality and morbidity, but there is no easy way to convert this into average reduction in number of years per 1000 population.

Most of the work which has attempted to place a value on environmental impacts has focused on health impacts rather than impacts on vegetation and ecosystems. The recent Department of Transport report *Valuation of Environmental Externalities* describes at some length various studies of the impact of pollutants on health. The valuation of these health effects avoid

attempting a measure of quality of life, but uses other techniques such as the hedonic price method. This measures the extra that people will pay for accommodation away from polluted or noisy areas.

An alternative technique for weighting the health impacts of different environmental effects is to use toxicity indices. Toxicity is a measure of the minimum level of concentration of a substance which will damage health. The lower this figure, the more toxic is the substance. 'Toxicity indices are base either on *a priori* scientific beliefs about the relative impact of various pollutants, or on the results of several different dose-response studies.' (*Valuation of Environmental Externalities*). The following toxicity indices are quoted in the Department of Transport publication. The massive variation in values is a warning of the difficulties with this approach.

Table: Toxicity indices from three studies

Study	VOC	NO_x	SO_2	CO
UIC (1987)	100	125	100	1
Prognos (1992)	100	40		0.2
Sweden (1992)	100	200	75	

Source: *Valuation of Environmental Externalities*

The Eco-indicator 95 also relies on toxicity indices to allocate weightings to health impacts. However, it then adjusts these to take account of a) the relative seriousness of the damage (damage weighting); b)the distance on average that actual concentrations are from levels which are critical for health (distance to target). The aggregate indicator of impacts is derived as follows:

$$I = \Sigma W_i * E_i/T_i$$

$$= \Sigma W_i * (E_i/N_i)*(N_i/T_i)$$

where

I	aggregate indicator
N_i	current extent of the effect (i) in Europe (or normalisation value)
T_i	target value for effect (i)
E_i	contribution of activity to effect (i)
W_i	subjective weighting factor for seriousness of effect (i)

and (N_i/T_i) is the ratio of distance to target, or the 'reduction factor' required, for effect (i).

For each health impact, the target level for toxicity (T_i) is chosen (as for ecosystems above) as 'the level where a demonstrable but limited damage occurs.' Damage weighting is applied between the group of pollutants within each effect, but not between effects, relying mainly on subjective evaluation. Eco-indicator decided to treat the following damage levels as equivalent:

- one extra death per million inhabitants per year
- health complaints as a result of smog periods

For each effect, average distance from target or reduction factor (N_i/T_i) is calculated as an average for Europe. This method allows for the fact that one additional unit of a pollutant which is well below toxic levels will be far less damaging than for a pollutant which is on or above critical levels. The resultant reduction factors and normalisation factors are shown below. We suggest that these are used to weight health impacts.

Effect	Units (for E_i)	Normalisation factor - per head of population in Western & Eastern Europe (N_i)	Reduction factor (N_i/T_i)	Overall weight: ($1/T_i$)
Ozone layer depletion	kg (CFC equivalent)	0.926	100	107.0
Winter smog	kg (SO_2 equivalent)	94.6	5	0.053
Pesticides	kg (active substance)	0.966	25	25.9
Heavy metals	kg (lead Pb equivalent)	0.0543	5	92.1
Carcinogenic substances	kg (PAH equivalent)	0.0109	10	917.4

Source: *The Eco-indicator 95*, Netherlands Agency for Energy and the Environment

These weights could provide a basis for translating these different health effects into a common measure of health (for want of a better term: 'health points'). The commensurability of these impacts with land footprints is discussed below.

1.2 Health & safety

The Eco-Indicator 1995 study does not include health and safety impacts (eg. road traffic accidents) as environmental impacts. However, the distance to target methodology can be used to derive a weighting for these too.

Current level of road accidents in Europe is approximately 10 deaths per hundred thousand people per year (ie. $N_i = 0.0001$). The target level would be one death per million people per year (ie. $T_i = 0.000001$). The reduction factor is 100 and normalisation factor is 0.0001. The overall weighting factor for deaths from road traffic accidents is therefore ($1/T_i$) = 1,000,000. (Note: Since the outcome of road traffic accidents is measured directly in fatal accidents, the target level itself defines the weighting.)

2. LOCAL ENVIRONMENTAL QUALITY

2.1 Possible model

This component of the eco-calorie would be concerned with the consequences of householders' environmental behaviour on the perceived quality of life of other people. Because ecological and health impacts are dealt with by other components, this comes down to the simple question: 'how much pleasure (or displeasure) does this behaviour cause to other people?' For consistency with the proposed measures of ecology and health, we need to measure the *impacts* of people's behaviour on the local environment, rather than simply measuring the *input*s of their behaviour. We propose a simple utilitarian model for this: the total quality of life effect of a bit of environmental behaviour is the sum of all the pleasurable and miserable reactions of others, and these can be quantified in terms of their *intensity* and *duration*.

Thus the positive effect of a beautifully kept window box is given by the number of people who see it, how much happier it makes them and for how long (minus the intensity times duration of the irritation caused to anyone passing by who happens not to like bright vulgar flowers, grinning gnomes or whatever). Similarly the negative effect of allowing a dog to defecate on the pavement will be given by the amount and duration of the mild depression caused to each of the people who see it (and the sharper irritation caused to those who fail to see it until too late).

2.2 Properties of this model

This model has some interesting properties:

i. 'Beauty is in the eye of the beholder'. Behaviour only matters in so far as others care about it. The model is profoundly 'social': the evaluation of an individual's effects depends on the views and values of his/her peers, not his/her own.

ii. The more densely peopled an area is, the more effect people can have on each other. City dwellers have bigger impacts - and arguably more responsibility to behave well - than rural dwellers.

iii. Behaviour close to the norm has much less effect than unusual behaviour (either good or bad). My beautiful window box will give less pleasure to passers-by if all my neighbours also have nice ones than if it is the only one in the street. Dropping the only crisp packet in an otherwise pristine garden square will cause more displeasure than dropping the hundredth one blowing around a neglected shopping street.

iv. It shares the feature of all utilitarian value systems that goods can offset bads. John Stewart Mill agonised over the implication that gladiatorial combat was morally OK provided only that the spectators got enough pleasure to outweigh the pain to the participants. In our model this takes the milder form that (for example) enough voluntary landscape work compensates for your litter-dropping and dog fouling.

We would suggest the first 3 of these are intuitively right but the fourth is problematic. We suggest a way to deal with it below.

2.3 Implementing the model

To implement this model we need to ask users to identify the ways they significantly affect other peoples' quality of life, and then form each of these estimate how many people are affected? How happy or sad? For how long?

For the middle of these we suggest a 'point' scoring from +/- 1 for the mildest reaction people are conscious of (eg most peoples' response to a window box or a crisp packet) through +/- 3 (seeing Durham Cathedral, or the Westway flyover, from a train window) and +/- 5 (picnicking in a sunny secluded chuchyard, or stepping in dog mess) to + / - 10 for the strongest feelings engendered by the environment - awe at first seeing St Pauls or a clear view from the top of Coniston Old Man; desperation at insomnia from neighbour noise.

We could call a pleasant effect of 1 point for 1 minute a 'smile'. If we called unpleasant effects 'frowns' instead of 'negative smiles' this could create a slight conceptual separation between positive and negative. If Going for Green wished to keep simplicity, a user's score could still be calculated by subtracting frowns from smiles. However it would also be possible to add them up separately, or to give frowns higher weighting than smiles.

We have provided a handful of worked examples for the most likely impacts on the local environment (see attached spreadsheet). We take as a unit (one 'smile'): one unit of mild pleasure (scoring one positive point) generated for an average of 50 people per day for a year. A 'frown' is the converse: one unit of mild annoyance (scoring one negative point) generated for an average of 50 people per day for a year.

The worked examples suggest that the following scores would be reasonable for activities which are likely to impact on the local environment.

Activity	Frowns	Smiles
Transport:		
- driving in urban area	0.005438 per km	
- driving in rural area	0.00137 per km	
- aeroplane take-off and landing	13.70 per round trip	
Water:		
- maintaining pleasant garden, visible to passers by (for a year)		2
House:		
-maintaining pleasant house appearance, visible to passers by (for a year)		1
- conversely, letting house become an eyesore	1	
Voluntary Activities:		
- keeping public area (equivalent to garden) clear of litter for a year		1
- creating a new greenspace or park visited by 100 people per day (for a year)		300
- maintaining/protecting a heritage feature visited by 10 people per day (for a year)		30
- creating a new work of art visited by 10 people per day (for a year)		30

3. COMMENSURABILITY OF FOOTPRINT, HEALTH AND LOCAL ENVIRONMENTAL QUALITY EFFECTS

The three types of impact measures discussed here and in Chapter 3 (ie. ecological footprint, health points and local quality points) are fundamentally incommensurable. The *Eco-Indicator* study brought health and ecological impacts into a single indicator by using a 'distance to target' methodology for weighting all of these impacts. However, we feel that the choice of targets and relative weight given to these impacts is highly arbitrary (eg. the methodology assumes an equivalence between 5% damage to the ecosystem and 1 death per million people per year). While recognising that a subjective weighting between 'ecological', 'health' and 'local environmental quality' effects will ultimately be needed if a single measure is to be derived, we feel that it is more meaningful for users to see their separate impacts in these three categories. This would mean being explicit about the default weightings between these categories and - importantly - giving users the chance to specify their own weightings. If a single measure is to be derived, we feel that the subjective weightings should ideally be derived through a formal 'Delphi' process: involving consultation with a panel of appropriate experts.

APPENDIX D

GOING FOR GREEN - FOOD PURCHASING

EMISSIONS FROM AGRICULTURE, MANUFACTURE AND DISTRIBUTION IN THE UK

Source: *The Pilot United Kingdom Environmental Accounts*

Emissions produced per every £1bil of food purchases bought at retail prices

Data as at 1993	Gross output £bil	Value added £bil	Value input £bil
Unprocessed food entirely sourced in the UK			
Agriculture, forestry & fishing	20	11	9.00
Distribution	145	79	66.00

Therefore £20bil output from agriculture leads to 43.94 £bil retail value

Therefore £1 billion of unprocessed food retail purchases produce these emissions:
(Agriculture emissions in 1993 / 43.9) + (Distribution emissions in 1993 /145)
if entirely sourced in the UK

Data as at 1993	Gross output £bil	Value added £bil	Value input £bil
Manufactured food entirely sourced in the UK			
Agriculture, forestry & fishing	20	11	9.00
Food processing & tobacco	62	18	44.00
Distribution	145	79	66.00

Therefore £20bil output from agriculture leads to 28.18 £bil factory gate value
and £28.18 bil from factory leads to 61.91 £bil retail value

Therefore £1 billion of processed food retail purchases produce these emissions:
(Agriculture emissions in 1993 / 61.91) + (Food manufacture emissions in 1993 x (28.18/62) / 61.91)
(Distribution emissions in 1993/145) OR

(Agriculture emissions in 1993 / 61.9) + (Food manufacture emissions in 1993 /136.2) +
(Distribution emissions in 1993 / 145)
if entirely sourced in the UK

NB. THIS IS ALL IN 1993 PRICES. THEREFORE PURCHASES WILL HAVE TO BE ADJUSTED BY THE RATE OF INFLATION FOR FOOD ITEMS SINCE 1993.

EMISSION FROM TRANSPORT FROM EUROPE AND REST OF THE WORLD

Sources: Social Trends, Annual Abstract of Statistics, Transport for a Sustainable Future, John Whitelegg, 1993.

Emissions g/tonne - km of freight transport

	Rail	Water	Road	Air
CO2	41.00	30.00	207.00	1206.00
CH4	0.06	0.04	0.30	2.00
VOC	0.08	0.10	1.10	3.00
NOx	0.20	0.40	3.60	5.50
CO	0.05	0.12	2.40	1.40

Source: J. Whitelegg

At an estimated average price of £1 per 0.5kg of food, or £1mil per 500 tonnes of food.

Therefore emissions g/£1mil -km of food transported

	Rail	Water	Road	Air
CO2	20500	15000	103500	603000
CH4	30	20	150	1000
VOC	40	50	550	1500
NOx	100	200	1800	2750

Food from Europe

Assume 100km by water and 1000km by road
Global Warming Potential (g CO2 equiv) = 1.07E+08
Acidification (g SO2 equiv) = 1274000
Summer Smog (g PCOP equiv) = 220890

Food from Rest of World

Sea and Road

Assume 6000km by water and 1000km by road
Global Warming Potential (g CO2 equiv) = 1.96E+08
Acidification (g SO2 equiv) = 2100000
Summer Smog (g PCOP equiv) = 338300

Air and Road

Assume 6000km by air and 1000km by road
Global Warming Potential (g CO2 equiv) = 3.79E+09
Acidification (g SO2 equiv) = 12810000
Summer Smog (g PCOP equiv) = 3800900

IMPACT OF ORGANIC FOODS AND MEAT

Source: Sustainable Consumption and the Consumer, Norwegian National Institute for Consumer Research, 1996.

The Norwegian report estimates that organic food only reduces environmental food-points from 200 to 180, but that the change from meat to vegetables is much more significant. This reduces food impact from 200 to 120 food-points.

EUTROPHICATION

Source: ADAS

Leachate of nitrogen and phosphate from agriculture:

Of the 18.5m hectares of land in UK used for agriculture, there will be leachate from the 12m hectares which are used for arable and intensive livestock. The remaining 6.5 hectares are rough grazing which will not have leachate.

Average leachate for the 12m hectares is:
25kg per hectare of nitrogen
2kg per hectare of phosphate

1 kg of nitrogen = 4.42kg of nitrate, therefore leachate of nitrates is:
110.5 kg per hectare of nitrates

Therefore average for all hectares of agriculture is:
71.68 kg per hectare of nitrates
1.30 kg per hectare of phosphate

According to Ecopoints:
1kg nitrate is equivalent to 0.42 kg NP equivalent
1kg phosphate is equivalent to 1 kg NP equivalent

Therefore average per hectare is: 31.40 kg NP equivalent per hectare.

Difference in application of fertilisers in Europe and Rest of World
Source: A Guide to the Global Environment, World Resources Institute 1996

Annual fertiliser use in 1993:

	kg per hectare	000 hectares cropland	Tot kg
Europe	116	136005	15776580
Africa	21	187887	3945627
North & Central America	95	271447	25787465
South America	59	102767	6063253
Asia	118	468661	55301998
Oceania	41	51500	2111500
UK	*338*	*6127*	2070926
ROW excl Europe	86	1082262	93209843

Therefore to adjust nutrophication for food from:

Europe = 10.78 kg NP equivalent per hectare
ROW = 7.99 kg NP equivalent per hectare

NB. This does not allow for the probable increased area needed to produce a £1b of food in countries where less fertilisers are used.

CALCULATING GLOBAL ENVIRONMENTAL IMPACT USING ENV. ACC EMISSIONS BUT ECO-INDICATOR WEIGHTS

With emissions from electricity reallocated to purchaser.

GLOBAL WARMING POTENTIAL

Using Eco-indicator rather than Environmental Accounts weights

	CO2	Methane	N2O	Meth as	N2O as	GWP
	tonnes	tonnes	tonnes	CO2 equ	CO2 equ	CO2 equ
Agriculture	4500000	1107300	9700	12180300	2619000	19299300
Food processing	19800000	1300	200	14300	54000	19868300
Distribution	21900000	1400	300	15400	81000	21996400

ACIDIFICATION	SO2 equ
	tonnes
Agriculture	567600
Food processing	224700
Distribution	196500

SUMMER SMOG	Benzene	VOC	Benzene	VOC as	Total PCOP
	tonnes	tonnes	PCOP equ	PCOP equ	equ
Agriculture	0	80.9	0	32.1982	32.1982
Food processing	0	86.9	0	34.5862	34.5862
Distribution	1.6	26	0.3024	10.348	10.6504

DEGRADED LAND	hectares
Agriculture & Forests	20400000

HEAVY METAL POLLUTION

	Lead
	tonnes
Agriculture	3.00
Food processing	10.10
Distribution	27.40

WINTER SMOG	black smoke
	tonnes
Agriculture	2.9
Food processing	9.4
Distribution	23.2

UNPROCESSED FOOD

Where:
Fuu is expenditure in £mil on unprocessed food from UK
Fue is expenditure in £mil on unprocessed food from rest of Europe
Fur is expenditure in £mil on unprocessed food from rest of the World
Fut is expenditure in £mil on all unprocessed food
Adjust expenditure on organic food to 90% of purchase value.
Adjust expenditure on meat to 166% of purchase value.

Global Warming Potential
Uses Eco-Indicator weights which differ from Environmental Accounts weights for GWP

grammes CO2 equiv	=	Fuu x	439619.6 +	151699.3
	=	Fuu x	591318.9	
	=	Fue x	591318.9 +	5.35E+07
	=	Fur x	591318.9 +	1.96E+08 by sea
	=	Fur x	591318.9 +	3.79E+08 by air

Acidification

grammes SO2 equiv	=	Fuu x	12929.38 +	1355.17
	=	Fuu x	14284.56	
	=	Fue x	14284.56 +	637000
	=	Fur x	14284.56 +	2100000 by sea
	=	Fur x	14284.56 +	12810000 by air

Summer smog

grammes PCOP equiv	=	Fuu x	0.733444 +	0.073451
	=	Fuu x	0.806895	
	=	Fue x	0.806895 +	110445
		Fur x	0.806895 +	338300 by sea
		Fur x	0.806895 +	3800900 by air

Biomass land

hectares	=	Fuu x	0.464692	
	=	Fue x	0.464692 x	2.912801
	=	Fur x	0.464692 x	3.929912

Heavy metal pollution

grammes lead	=	Fut x	0.068337 +	0.188966
	=	Fut x	0.257303	

Winter smog

grammes black smoke	=	Fut x	0.066059 +	0.16
	=	Fut x	0.226059	

Nutrophication

grammes NP equivalen	=	Fuu x	0.464692	x	31400
	=	Fuu x	14591.34		
	=	Fue x	0.464692	x	10780
	=	Fue x	5009.38		
	=	Fur x	0.464692	x	7990
	=	Fur x	3712.89		

	grammes	add packaging		1995 price (Social Trends)	price/kg (calc)	(assume/ average)	comments	1994 exp. (Annual Abstract) (millions £)	Adjust to mid-1995 prices	implied kg (millions)
beef	500	550		236	429	353	average of beef/bacon	10558	10907	3092
bacon	500	550		152	276	(included		see beef		
cheese	250	275		115	418	above)		see milk		
butter	250	275		78	284	187	average of butter/marg	1056	1091	583
potatoes	1000	1100		77	70	70		2356	2434	3477
large loaf	800	880		74	84	84		1991	2057	2446
sugar	1000	1100		72	65	65		288	298	455
tea	125	138		63	458	458		1268	1310	286
6 eggs	300	330	(how mar	59	179	(included		see milk		
margarine	500	550		50	91	above)		see butter		
milk	568	625	(1 pint)	36	58	218	average of milk/cheese/e	6082	6283	2879
cakes & biscuits						168	twice price of bread	2181	2253	1340
other cereals						168	ditto	2572	2657	1580
fish						353	same as beef/bacon	1706	1762	500
fruit						200	double price of veg	3021	3121	1560
veg						100	slightly more than potatoe	4019	4152	4152
confectionery						200	slightly more than cakes	4624	4777	2388
soft drinks						150	say 50p per can	3316	3426	2284
other manufactured food						353	same as beef/bacon	2343	2420	686
									0	
							total:	47381	48946	27707
							implied average price (1995 £/kg):			1.71

EcoCal Market Testing Results

EcoCal

EcoCal Market Testing Results

Prepared by
Craig Simmons (UserData)
Nicky Chambers (PULSAR International)

Details of Market Testing

- 3 Regions - Huntingdonshire, Lancashire, Stirling
- 7 Venues
- Total of 90 persons tested (67 households)
- Split between paper-based (ECP) and computer-based (ECC) versions of EcoCal
- All persons given before and after attitude questionnaires and usability questionnaire

Results Summary: Passes/Fails

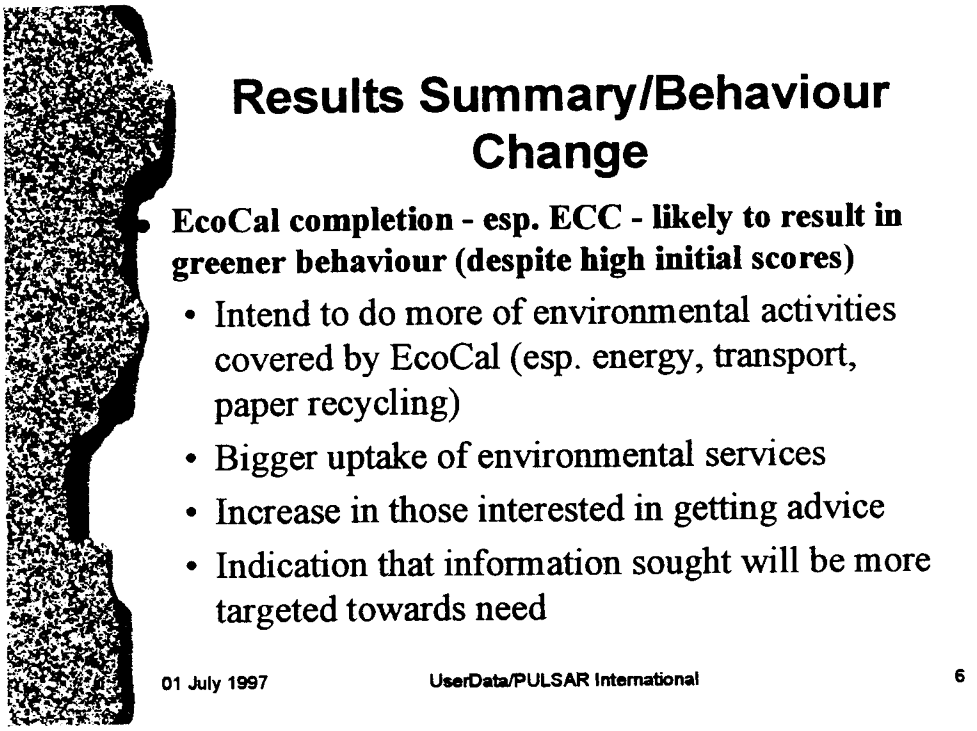
- Problems with calculations gave lower pass rate on ECP (64%) than ECC (74%)
- Simplifying ECP calculations could increase pass rate to more than 75%
- Simple change to ECC user interface would boost pass rate to 86%
- Very high ECC pass rate given that 45% of ECC users new to computers

Results Summary/Usability

- ECC easier to use than ECP (74% -vs-50%)
- ECC easier to learn than ECP (76% -vs- 60%)
- ECP supporting materials seen as better than ECC materials (82% -vs- 76%)
- Overall more satisfied with ECC (83%) than ECP (73%)
- More likely to refer to ECC on-screen facts, hints & tips etc. than ECP booklet contents

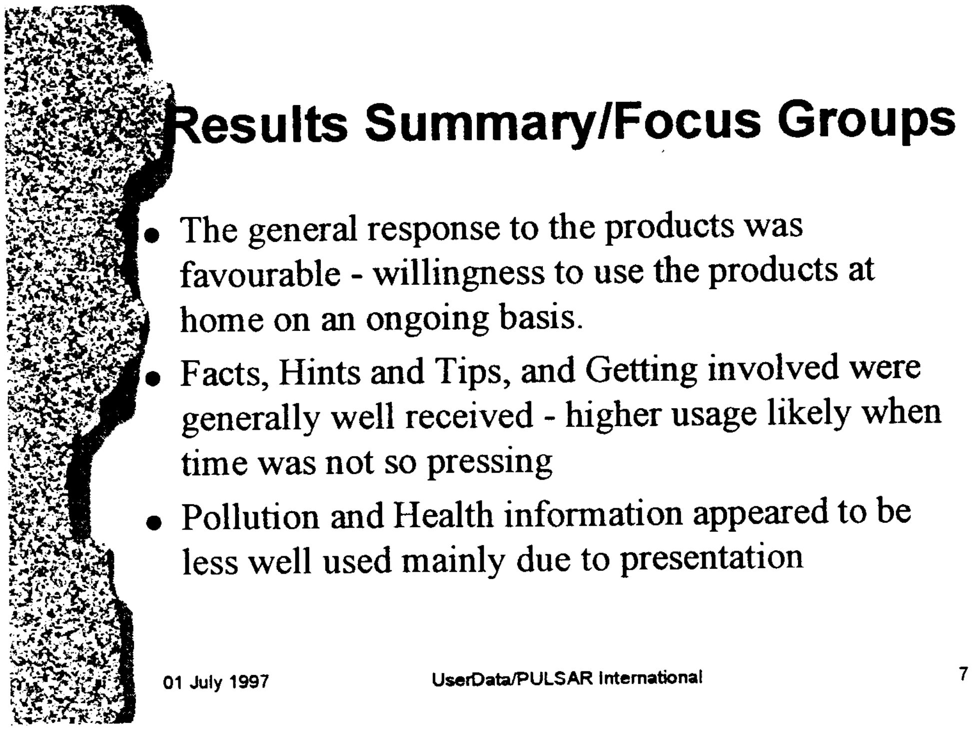
Results Summary/Attitudes

- Increase in those 'concerned' about environment after completing EcoCal (ECC & ECP)
- Increase in those believing they could personally do a 'lot more' to help environment
- Marginal increase in those feeling they would like to do more
- Still give same 'barrier' reasons for not doing more but increase in 'not sure' suggests unmet need for information



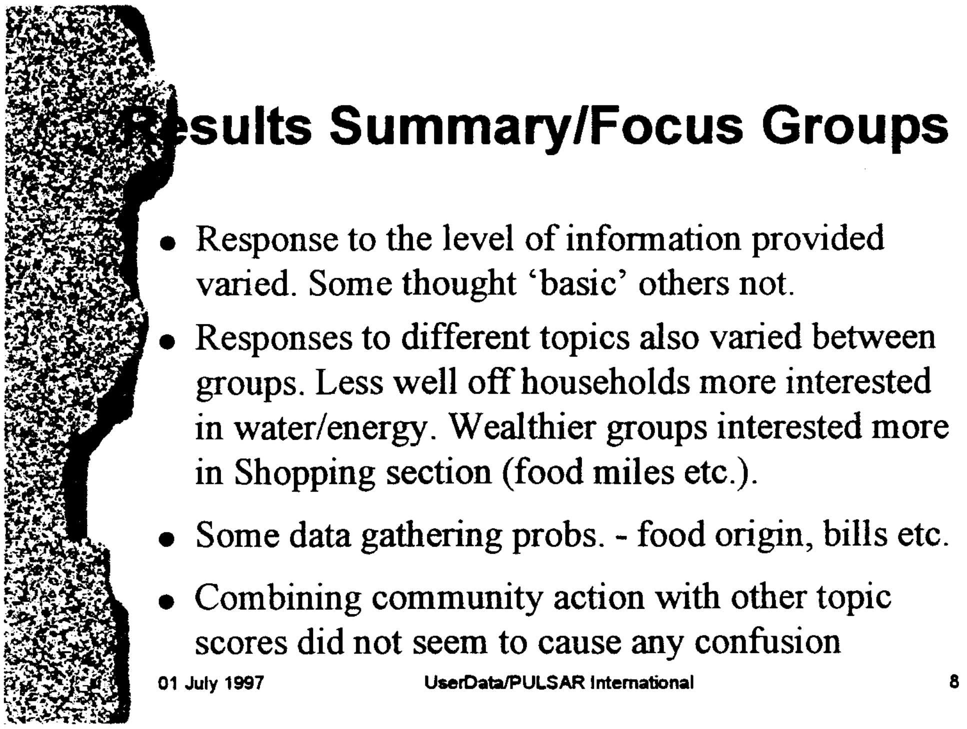
Results Summary/Behaviour Change

- **EcoCal completion - esp. ECC - likely to result in greener behaviour (despite high initial scores)**
  - Intend to do more of environmental activities covered by EcoCal (esp. energy, transport, paper recycling)
  - Bigger uptake of environmental services
  - Increase in those interested in getting advice
  - Indication that information sought will be more targeted towards need



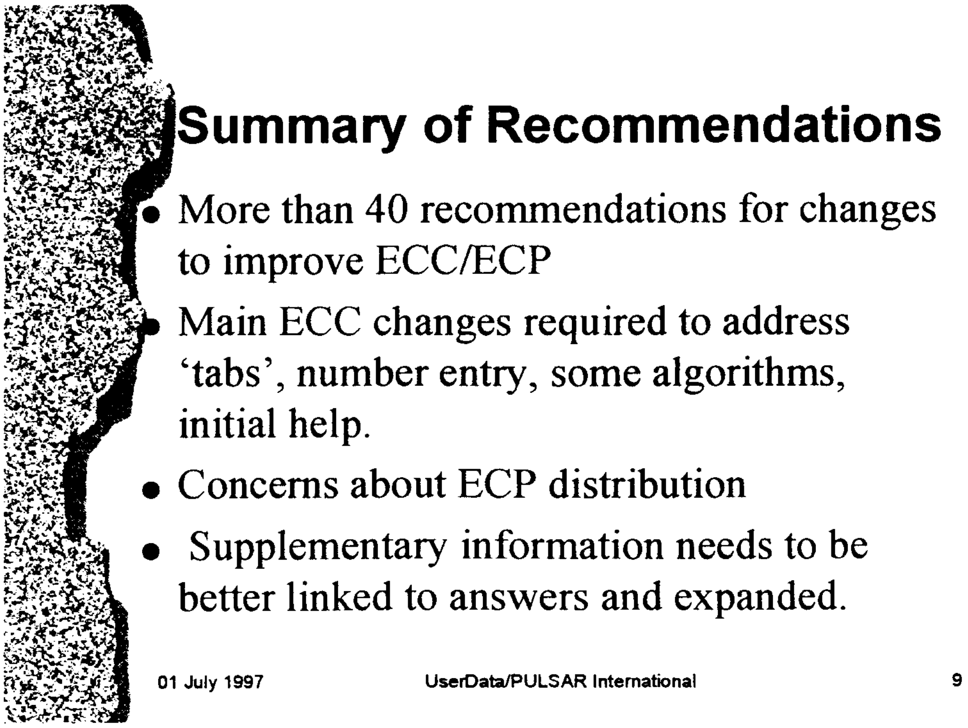
Results Summary/Focus Groups

- The general response to the products was favourable - willingness to use the products at home on an ongoing basis.
- Facts, Hints and Tips, and Getting involved were generally well received - higher usage likely when time was not so pressing
- Pollution and Health information appeared to be less well used mainly due to presentation



Results Summary/Focus Groups

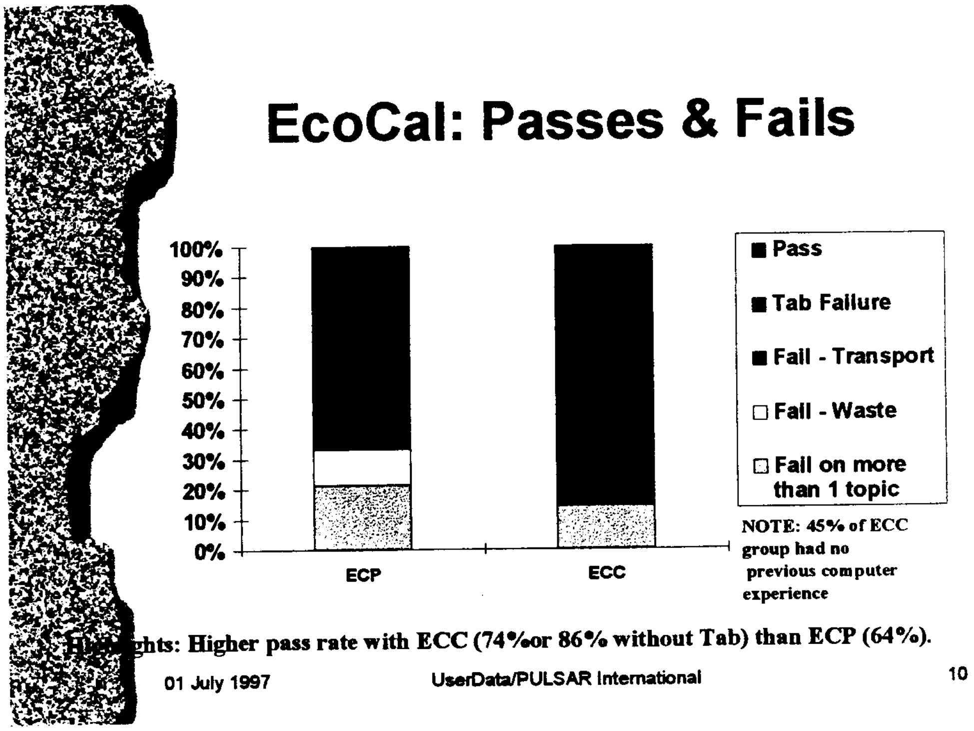
- Response to the level of information provided varied. Some thought 'basic' others not.
- Responses to different topics also varied between groups. Less well off households more interested in water/energy. Wealthier groups interested more in Shopping section (food miles etc.).
- Some data gathering probs. - food origin, bills etc.
- Combining community action with other topic scores did not seem to cause any confusion



Summary of Recommendations

- More than 40 recommendations for changes to improve ECC/ECP
- Main ECC changes required to address 'tabs', number entry, some algorithms, initial help.
- Concerns about ECP distribution
- Supplementary information needs to be better linked to answers and expanded.

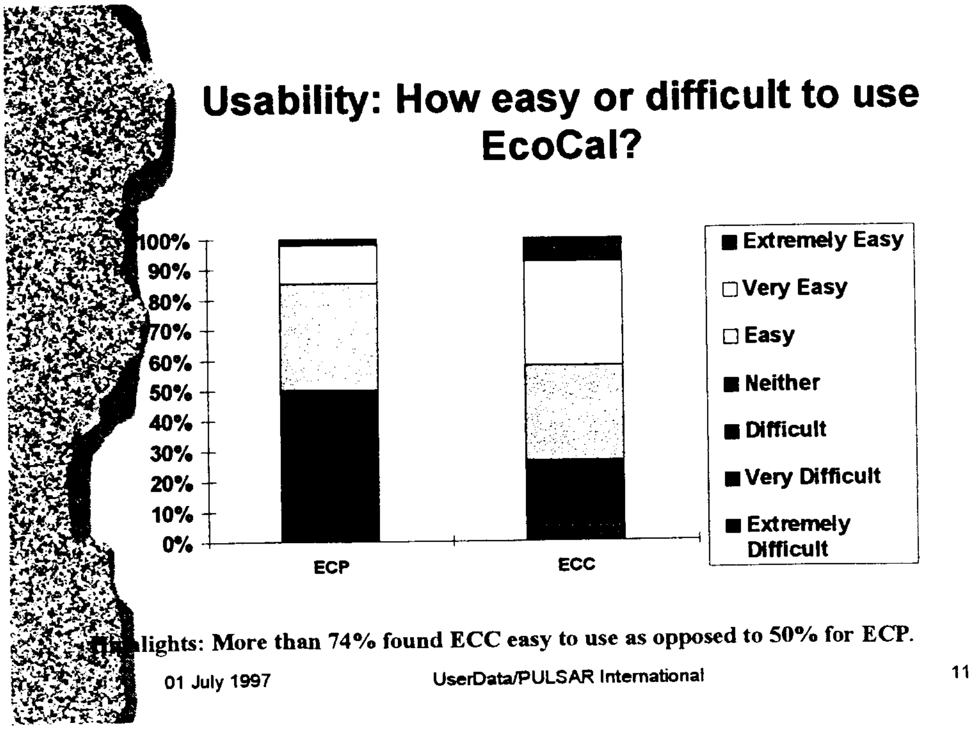
EcoCal: Passes & Fails



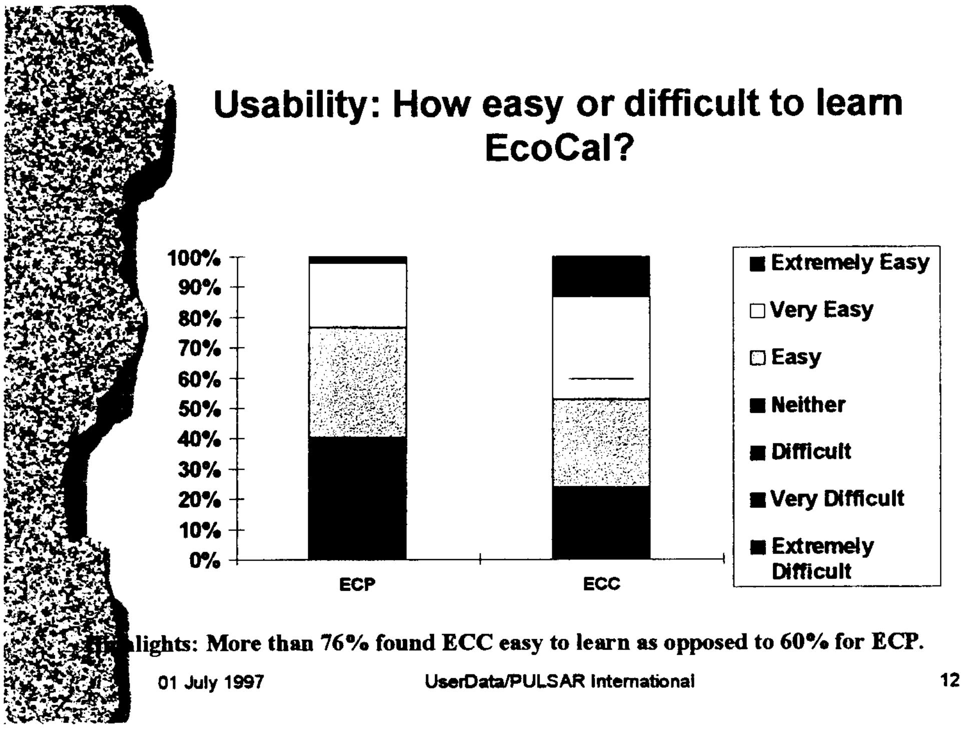
NOTE: 45% of ECC group had no previous computer experience

Highlights: Higher pass rate with ECC (74%or 86% without Tab) than ECP (64%).

Usability: How easy or difficult to use EcoCal?

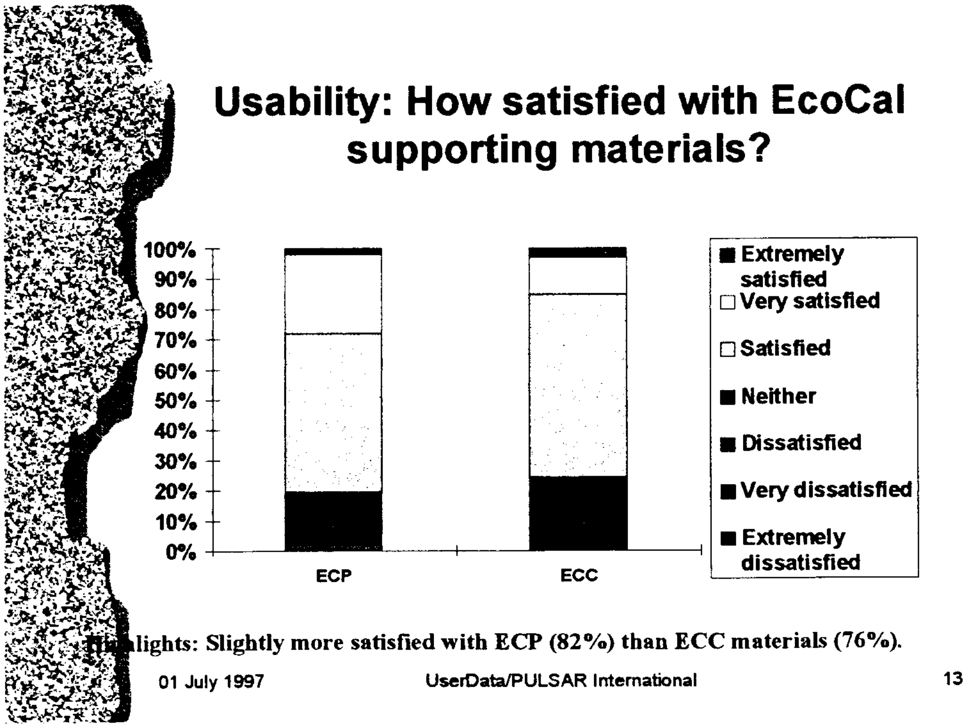


Highlights: More than 74% found ECC easy to use as opposed to 50% for ECP.



Usability: How easy or difficult to learn EcoCal?

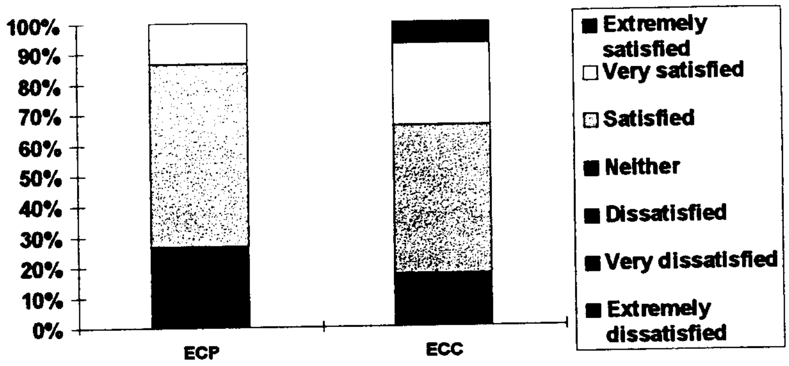
Highlights: More than 76% found ECC easy to learn as opposed to 60% for ECP.



Usability: How satisfied with EcoCal supporting materials?

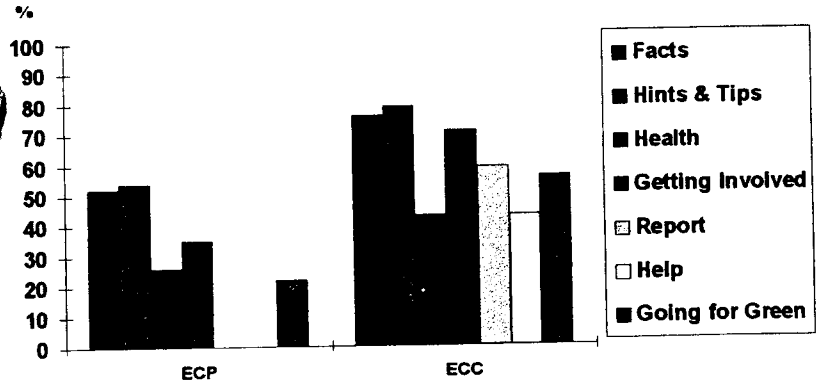
Highlights: Slightly more satisfied with ECP (82%) than ECC materials (76%).

Usability: Overall satisfaction with EcoCal?

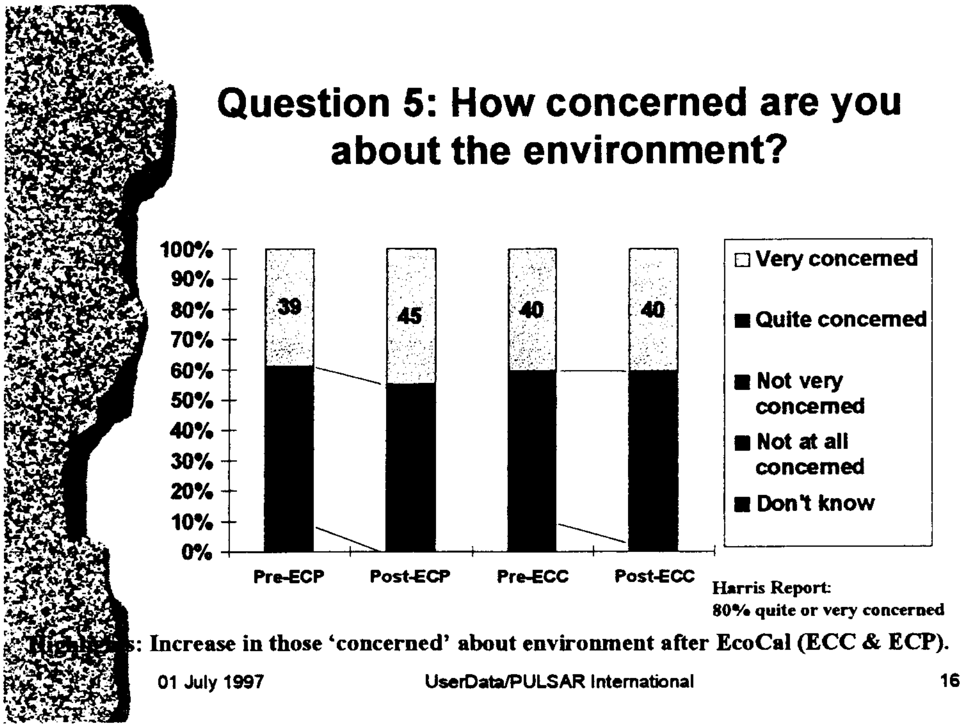


ighlights: More satisfied with ECC (83%) than ECP (73%).

Usability: Which additional parts of EcoCal referred to?



ights: Users more likely to access info on-screen (ECC) than in booklet (ECP).



Question 5: How concerned are you about the environment?

Harris Report:
80% quite or very concerned

Highlights: Increase in those 'concerned' about environment after EcoCal (ECC & ECP).

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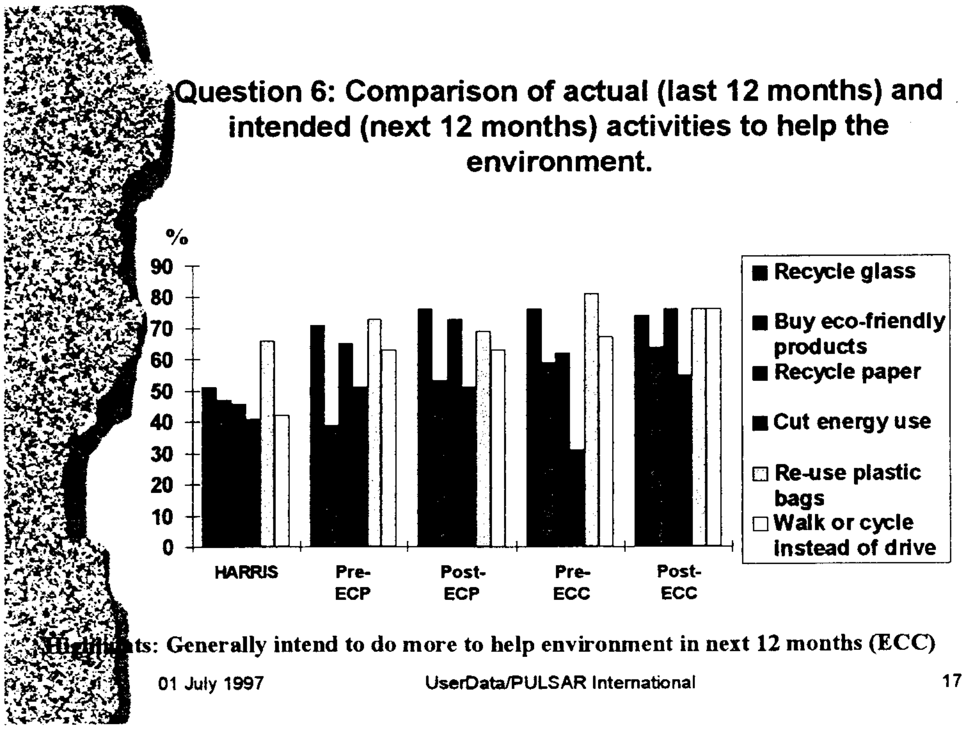

Question 6: Comparison of actual (last 12 months) and intended (next 12 months) activities to help the environment.

Highlights: Generally intend to do more to help environment in next 12 months (ECC)

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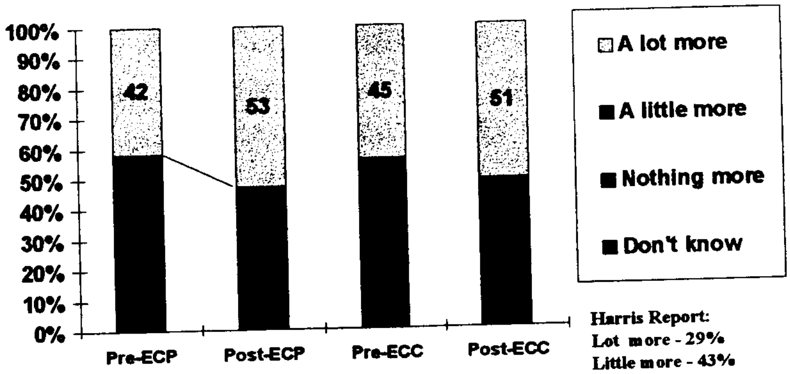
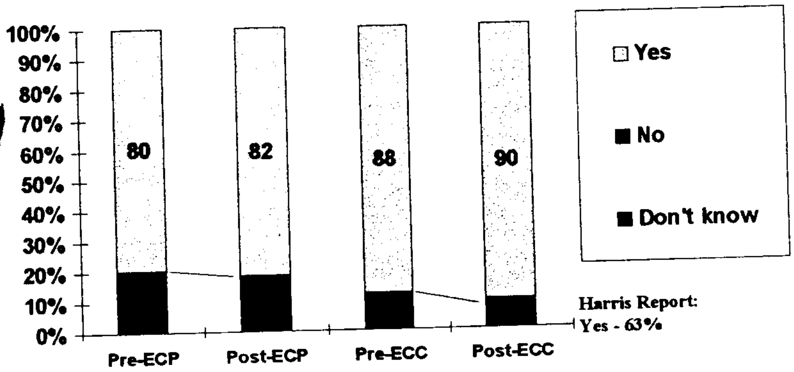
Question 7: How much more, if anything, could you personally do to help the environment?



Harris Report:
Lot more - 29%
Little more - 43%

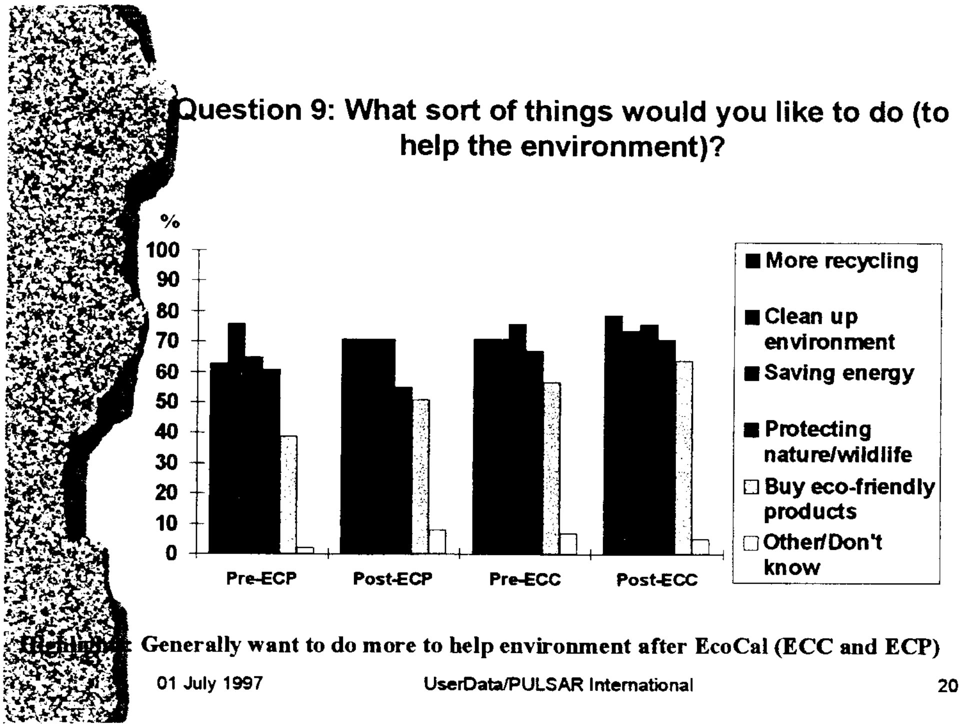
ghts: Increase in those believing they could do a 'lot more' (ECC and ECP)

Question 8: Do you feel you would like to be able to do more to help protect the environment?



Harris Report:
Yes - 63%

hlights: Marginal increase in those feeling they would like to do more for the ironment (ECC and ECP)



Question 9: What sort of things would you like to do (to help the environment)?

Highlights: Generally want to do more to help environment after EcoCal (ECC and ECP)

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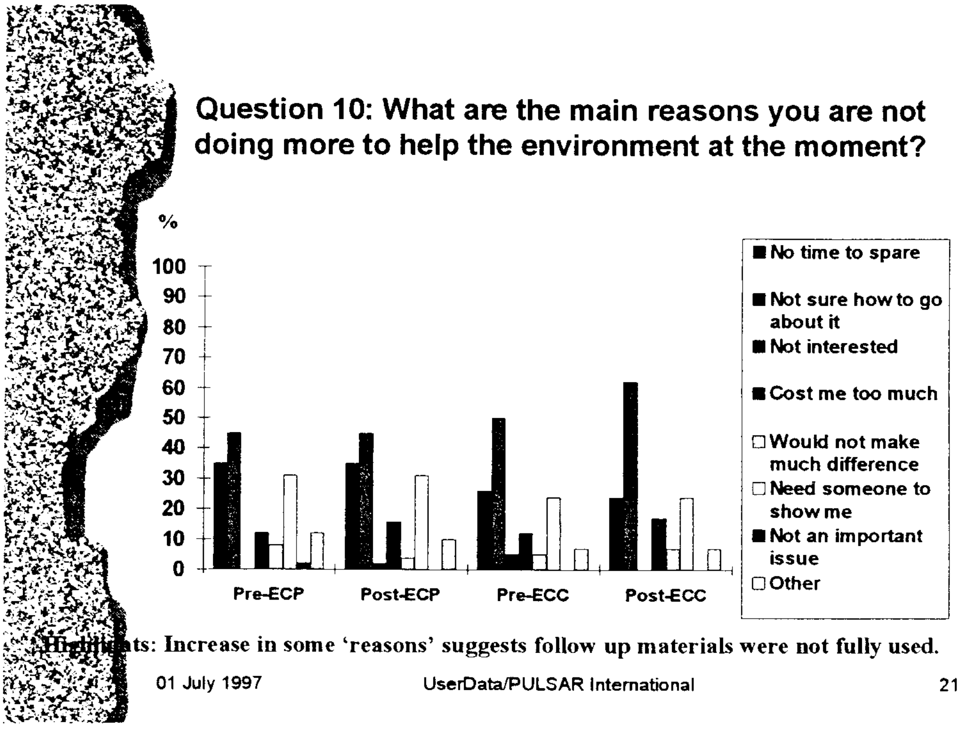

Question 10: What are the main reasons you are not doing more to help the environment at the moment?

Highlights: Increase in some 'reasons' suggests follow up materials were not fully used.

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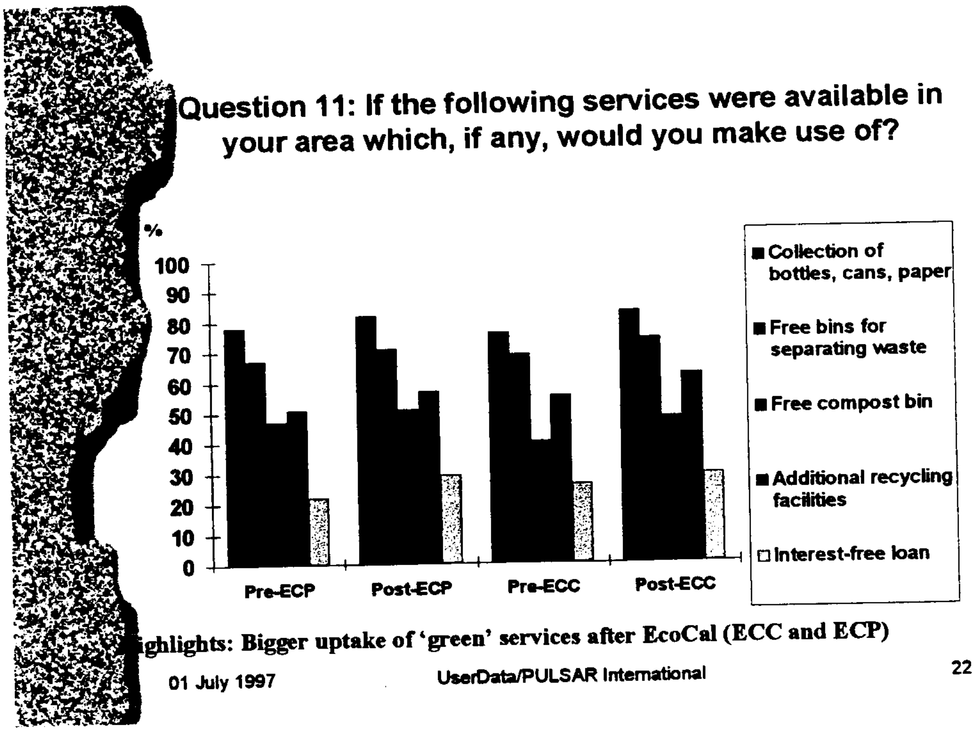

Question 11: If the following services were available in your area which, if any, would you make use of?

ghlights: Bigger uptake of ‘green’ services after EcoCal (ECC and ECP)

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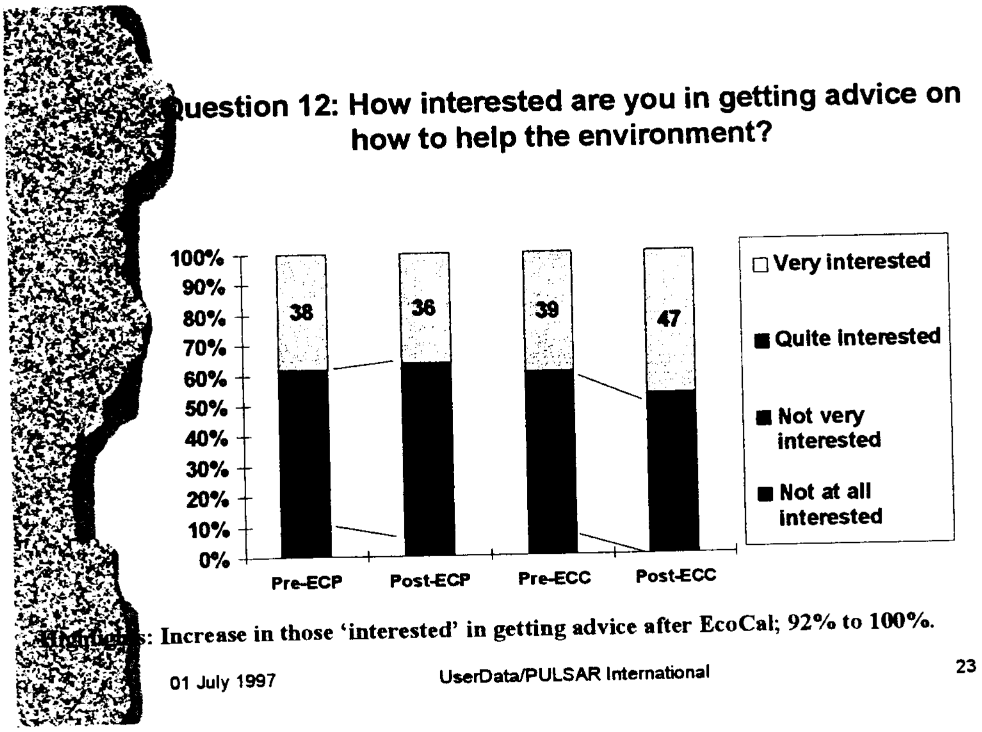

uestion 12: How interested are you in getting advice on how to help the environment?

s: Increase in those ‘interested’ in getting advice after EcoCal; 92% to 100%.

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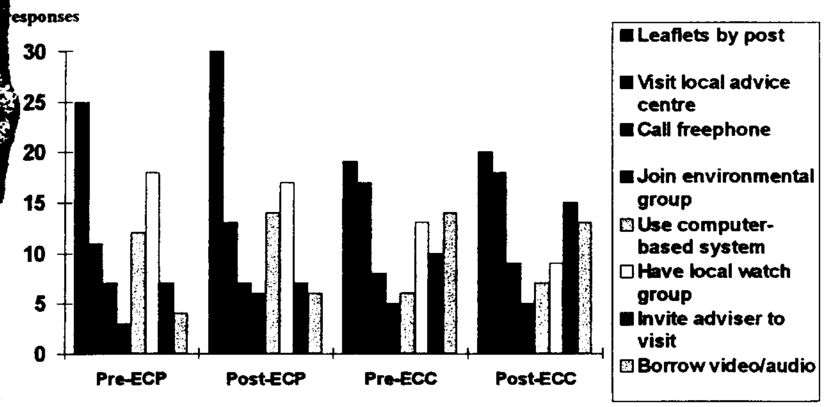
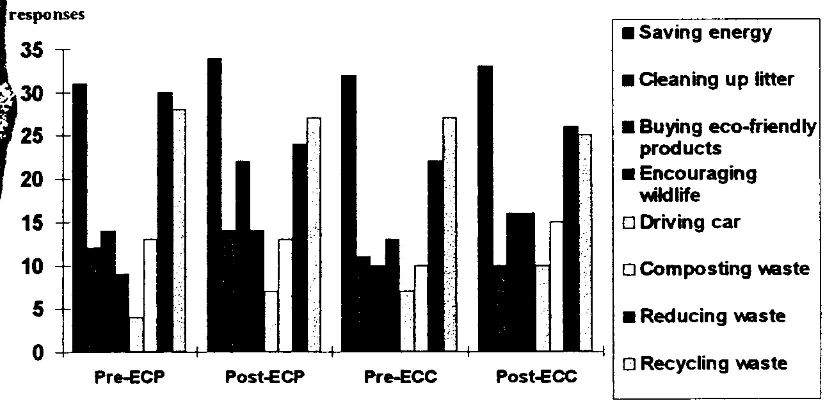
Question 13: How would you prefer advice to be provided?



ighlights: Seem generally more receptive to advice after EcoCal (ECC).

Question 14: What do you think you might like advice about?



ighlights: Seem generally more receptive to advice after EcoCal (ECC).

UserData
PULSAR International

Report

Market testing the Eco Cal:

Focus Group Summary and Recommendations

Prepared for Going for Green

by

Craig Simmons
UserData

Nicky Chambers
PULSAR International

29 June 1997

Introduction

UserData/PULSAR International have conducted market testing trials of the EcoCal product (both computer based (ECC) and paper based (ECP)) as per proposal of 7th January 1997.

Trials were carried out with household numbers as follows

	ECP	ECC
Huntingdonshire:		
Holywell	5	5
St Ivo Centre, St Ives	5	5
St Neots	3	3
Stirling		
Kippen	4	6
Fallin	6	4
Lancashire		
Eccleston	6	5
Burnley (2 sessions)	3	7
TOTAL	32	35

This report outlines focus group findings and sets out the general recommendations arising from the market testing trials.

Focus Group Findings

Households in each session took part in a short focus group after completion of the EcoCal to gain an understanding of the wider issues, opinions and feedback responses.

Issues common to ECC and ECP

The general response to the products was favourable and we were encouraged by the expressed willingness to use the products at home on an ongoing basis. This was also the case for those who had not previously used a computer.

"As I didn't know about computers I thought it was quite easy to use" (Holywell ECC)

Facts, Hints and Tips, and Getting involved were generally well received and if users did not use them in the trials they expressed a likelihood to use them when time was not so pressing (for both ECC and ECP). Pollution and Health information appeared to be less well used, although this may be partly due to its presentation, and the wording of the text was felt to be difficult by some users.

Response to the level of information provided varied between groups. Some more aware households found information in Hints and Tips very basic although many found them useful as a reminder/checklist.

"The Hints and Tips were rather patronising but I suppose there are some things that I'm not already doing" (Holywell ECC)

" I thought the report bit was good - it showed where you could do better but the hints and tips could have given more direct information (Kippen ECC)"

Less aware households found much of the information in Hints and Tips to be new to them.

"It made me think. The bits on saving electricity were good." (Fallin ECC) "I haven't had a chance to read all the book - can I take it with me?" (Burnley ECP)

Responses to different topics also varied between groups. Less well off households for example were less interested in the Shopping section for example and more interested in the energy and water sections.

"I was surprised I used so much gas ... and water! It made me think." (Lancashire ECC).

Better off households however believed themselves to be aware of energy saving issues but were interested in the concept of food miles and environmentally responsible shopping.

" Even though difficult to answer, the food miles bit was really interesting - I hadn't really thought about it before" (Holywell ECC).

Where difficulties arose with using the products, it was often a data gathering problem rather than a usability problem e.g. not knowing where food products come from, confusion about elements to include or not to include, not knowing how much is spent on bills, not knowing distances of travel. Some of these difficulties could be minimised by more guidance in the notes sections. This was the case for both the ECC and the ECP.

Although Going for Green had concerns about presenting a combined score for topics and Community Action the current presentation did not appear to cause users any confusion. Green Smileys were well received.

"I liked it when I got four - I felt happy (Kippen ECC)'

ECC specific issues

Most, though not all, households felt that if they had access to the ECC at home they would use it on an ongoing basis to measure their score.

"I'd like to have that at home - I'd use it I think."(Unprompted, Holywell ECC)

Response to proposed use with public access points was less favourable despite the fact that the usability test results would suggest that walk-up use would be feasible.

"I wouldn't use it - I wouldn't use it in the library" (Fallin ECC)

The product has been designed to guide users to Hints and Tips for information on how to reduce the household score. While some users followed this sequence there was a feeling that there could be a tighter link between scores and Hints and Tips.

ECP specific issues

The general response to the ECP was less favourable than to the ECC with it seeming to be more a chore than a game. A number of users referred to 'doing exams again', though indicated that they would have completed the questionnaire in a home environment.

Difficulties with the calculations seemed to be the primary barriers to successful completion and although comparison charts were provided in the supplementary materials, the paper based version did not provide the immediate competitive spirit engendered by the ECC!

"I wanted to know why mine was 3 times as much as hers and their house is the same as mine!" (of electricity bills, Holywell ECC)

The nature of the ECP, with more room for incorrect completion and less user friendly ways of comparing scores, makes it less likely that the user will be confident of having completed it successfully. This may discourage the user from repeated use and lead to confusion when interpreting scores.

The ECP questionnaire and supporting booklet, does not lend itself to making links between Facts, the user's score for particular topics and Hints and Tips to improve the score. Although these could be drawn together by a different presentation (see Recommendations) the links will never be as immediate as is possible with the ECC

Recommendations

The following recommendations arose from observations during the trials and from feedback during the focus groups sessions.

The Topics

Instruction page

- As the ECC product will be used by those unfamiliar with common computer protocols it is recommended that an initial instruction page is inserted between the Household information screen and the main body of pages. This could be linked in with save and report functions under development such that it appears only for new users.

Transport.

- Business travel. There were numerous discussions as to whether to include business travel due to lack of individual choice about travelling for work. It is recommended that separating business and domestic travel is considered.

- Weekly vs yearly travel. A number of users found it difficult to estimate yearly bus and train mileage. It is recommended that either public transport mileage is presented as weekly or preferably, an onscreen calculator is provided for this and other sections.

- Additional guidance on issues such as average fuel consumptions, and a conversion between cost and fuel use is worth considering.

Energy

- A considerable number of users use pre-pay cards for their electricity. It is recommended that the algorithms are revisited to ensure that the price differential is not significantly affecting performance ratings. Similarly for Economy 7 electricity.

- Many household appeared to be 'in the red' for energy. It is recommended that comparative data is checked.

- As not all bills put kWh as units, it is recommended that more guidance on this is added in the notes.

Water

- Bearing in mind the increase in provision of water meters, it is recommended that a facility for direct insertion of water used is provided in this or later versions.

- Consider car washing implications - additional question or add to hosepipe usage.

Shopping

- Luxury (hotels) should be defined as 3* and above.

- It is recommended that free newspapers are included in newspaper purchasing with hints and tips suggesting declining free newspapers if they are not required.

- More guidance should be provided on where food products come from (e.g. menu presentation) and for items such as the size of bags of coal, peat, gas bottles, washing powder containers (if this question is to remain).

- Provide more flexibility for % of organic or meat products.

House and Garden

- Many people were demotivated by having a higher score for House and Garden as a result of including all land even if under production for vegetables or wood. It is recommended that bio-productive areas are taken out of the equation.

- Recommended change of wording for size of land and additional guidance on calculating land area.

- Users did not know what hardwood was, and further notes are recommended.

Waste

- Many focus group discussions turned to local reasons why it was not possible to recycle. It is recommended that local recycling information is put in and cross referenced wherever possible.

- As previously discussed, the waste algorithm should be revisited.

Community Action

- We recommend clarification on the inclusion of environmental voluntary work as well as community work.

Hints and tips -

- It is recommended that closer links are made between answers to questions and final scores.

Getting involved

- It is recommended that organisations featured in Getting Involved provide logos, are notified of their presence on the EcoCal and produce co-branded material for distribution in the event of a rush of requests!

- Local information and 'national' information for Scotland, Wales and N. Ireland should be considered.

ECC specific issues

- It is recommended that the health button is moved to the bottom of the screen with H&Ts etc.
- A 'Back' button for Hints and Tips is recommended.
- Printing - clarification of check boxes required
- The most common cause of failure was finding tabs. It is recommended that a 'next page' facility or highlight labelling is added.
- Although dials were favourably received, some users new to computers missed them while concentrating on the rest of the screen. It is recommended to change dial with focus from subdued to primary colour version.
- Re-align print window so that all buttons are visible on smaller screens
- Investigate possibility of increasing size of up/down buttons.
- Bug in Community action reporting. Check criteria for displaying reporting comments.
- Remove 'eye' icon from help page and replace.
- Re-visit increments for up/down arrows
- Need to be able to type in numbers not just use arrows

ECP specific issues

Due to the high failure rate in completing the ECP we do not recommend that is is distributed for use without further design work. Ultimately, there is likely to be a high failure rate unless the calculations are greatly simplified or a tear-off return slip is used. It has the potential to be a good community environment development tool and, as such, has much to recommend it. In its current form we do not believe it is suitable for individual household use. We therefore recommend that Going for Green re-consider the role of the ECP.

Recommendations for simplification include the following:

Questionnaire

- Addition and subtraction signs should be more prominent particularly for the Waste section where users add scores rather than subtracting as intended.
- Some users had difficulties adding across-ways. It is recommended that the layout is amended to allow adding calculating vertically.

Supplementary Materials

- The booklet was not greatly used during completion though sometimes after completion. It is recommended that the layout and presentation is amended to take the user logically from facts, to guidance on the filling in the questionnaire, to the questionnaire itself (as centrefold pullout section for repeat completions) to interpretations of scores, to hints and tips and getting involved.

- Few awarded themselves any Green Smileys and it is recommended that this is revisited to emphasise this aspect.

- Check conversion charts for accuracy - add in additional charts as required

- Simplify wording of pollution and health.

Going for Green
Making a world of difference–together

EcoCal Market Testing

Market testing the EcoCal took place in seven communities participating in Going for Green's Sustainable Communities Project between 8 - 30 May 1997.

Market testing was facilitated by consultants from UserData and Pulsar International and their report is due for discussion at the meeting on Wednesday 2 July.

The following paper is a record of the comments made by households who took part in the testing. Ten households from each community participated, half testing the paper and half the computer versions of the questionnaire.

Following a summary of the main points made by households, the paper sets out the principal areas where revisions to EcoCal may be considered, the full record of comments made in each community is then presented.

The report given at the end was compiled by Tidy Britain Group's IT department and records the difficulties experienced by the Group when installing EcoCal discs under some circumstances.

EcoCal Market Testing Results

CONTENTS

EcoCal market testing results summary

COMPUTER

Given below is a summary of the main comments made by those households taking part in the market testing of the computer based EcoCal questionnaire.

General Comments

- Fun to do and easy to use
- Users keen to have direct entry of answers, arrow keys were found to be frustrating to use
- Some would have liked to press a button to find the reduction in score possible, if eg their travel was reduced by 50%
- The dials were not prominent enough, they were sometimes not seen to be changing
- Users often failed to find the extra pages of questions, the tab buttons were not recognised as page turners
- A child's version would be welcomed with lots of colour and images, asking children about the products they use, waste and litter, walking and cycling and processed food

Transport

- A strong desire to be able to differentiate between business and pleasure mileage
- Strong feeling that not fair if overall score is biased by car use when this is a necessity in some cases

Energy

- When bills were paid by standing order, consumption often not known
- Many households did not find their gas or electricity bills easy to read

Water

- Users found it difficult to estimate their hours of hose pipe use
- For houses that are metered, an option for direct entry of total use was requested
- A question about water use for washing cars was requested, being the main water use in some places
- Users would like to be rewarded for reducing flushing the toilet or turning off taps

Shopping

- Households found the origins of their food very hard to know
- People were curious about being asked for the source of food, there was a feeling they were being pressured into only buying British goods
- Typical comments: "The wide range of products available now is good and what's wrong with having strawberries all year round?"
- "What about support for third world economies?"
- "Shopping is hard enough already without having to read labels"

- Users were curious that no direct question was asked about locally grown vegetables or whether recycled or CFC free products were bought
- Users were unclear about what should be considered a "luxury" hotel and also why newspapers and stays away from home were particularly asked about
- Some users would have been happy to spend more time answering questions about other purchases

House & Garden

- Many users were uncomfortable about being penalised for having a large garden
- More help was needed on calculating areas, also conversion from feet to metres
- Further guidance on what should be considered "peat" and tropical hardwoods was requested

Waste

- Information about where to recycle things locally was asked for
- Users felt to be unfairly penalised if they would like to recycle but couldn't because of a lack of facilities

Community Action

- Users not clear what constitutes "community" action, advice on whether this should be environmental work only was requested

Getting Involved

- List of addresses alone was not thought to encourage getting involved
- Something about what the organisations did was requested
- More local information was wanted

"Did you know?"

- More personal facts were considered better than the straight statistics
- "The facts should relate to you and your household and not be general"

Help button "?"

- This button was generally not seen or used, but appreciated once pointed out
- Some users didn't think they could press on the question mark, it was not recognised as a source of help
- Sometimes found not to be much help when used, different answers from those provided were wanted

Hints and Tips

- Only looked at in passing as no real link being made to individual scores.
- Greater emphasis given to cost savings available was requested
- Some would have liked something to show what happens to their score if eg started to recycle bottles
- Others would have liked it to set a series of challenges, eg put a brick in the cistern this week and see what happens
- When a high score was recorded, users found it difficult to go back and find out why

Health Button

- Few found the button, those that did, found it at the end and not when flashing
- Information thought to be limited
- When seen flashing it was thought to mean the user had done something wrong

Report Button

- More information was wanted in the report, especially suggestions for things to do where a score is in the red
- The whole screen could not be seen
- No clear exit from the report is given
- "Would be nice to know what average scores are, as well as knowing you're better/worse than average"
- "Interesting to relate to what is sustainable rather than a comparison against an average"

Going for Green Button

- Many users saw the photographs and didn't look any further
- The information was thought to be people's life histories

EcoCal market testing results summary

PAPER

Given below is a summary of the main comments made by those households taking part in the market testing of the paper based EcoCal questionnaire.

General Comments

- Interesting, helped user to think about the environment more
- Appeared a little complicated at first, but fine once in the swing
- Problems were experienced with conversion between imperial and metric units
- Use of decimal places were found to be unnecessarily complicated and many people were unfamiliar with using a calculator

Booklet

- Handbook was not generally used to help complete the questionnaire
- Some only read the notes when couldn't answer the question, then it was helpful
- Notes for completing the questionnaire were found to be more helpful than the hints and the fascinating facts
- Users did not receive enough information on what to do about getting a high score
- Hints and tips were requested, emphasising where the user could best spend effort, perhaps giving a checklist of priority actions
- Many of the hints were thought to be pretty self evident
- Getting involved did not have local addresses and so was not of great interest
- Health information not thought to be of relevance and often not read
- "Too many big words in health impacts"

Transport

- Score dominated by business travel, users wanted to be able to separate out from family travel
- Money spent on petrol often known, but not number of litres used

Energy

- Information hard to read from bill

Water

- Questions were requested on toilet flushing and washing cars
- Hose pipe use was found to be hard to quantify
- Some felt cheated that they could not record and be rewarded for specially bought, water-saving washing machine, also credit was wanted for using a water butt
- An option to state total use was considered to be helpful for people with meters

Shopping

- Users found difficulty sorting out which food items came from where and how they were transported
- A sample shopping list with details of where products are from and how they arrived was requested

House & Garden

- Users were unclear why they were being asked about their houses
- Gardens were thought a benefit and users were unhappy at being penalised over size
- A bonus was wanted for those growing their own food
- More guidance was requested on calculating plot sizes
- Further guidance would also be helpful on tropical hardwoods

Waste

- Frustrating to be asked about plastic recycling when not available

Community Action

- This section was not well used
- More guidance on defining community/environmental action was requested

Interpreting Scores

- "A bit tricky to use at first and had to be explained"
- "Not done as too difficult"
- People were unable to find their score on the graph scale
- Some not very interested in comparisons with other households, as not easy to do

Issues to be addressed

Based on the feedback received and points raised during market testing, it is proposed that UserData/Pulsar International are asked to look again at the following issues.

General

1. *Further simplify the paper based calculations.* Many households represented did not have access to a calculator at home or were unfamiliar with its use. Extra help is needed with converting between imperial and metric units.

2. *Simplify use of language in both questionnaires.* Particularly, "Please type in a name or other text to identify your household" and wording of questions on where your food comes from.

3. *Re-consider design of handbook.* The handbook was referred to only as a last resort. Cross reference could be made between the questionnaire and the handbook. The hints and tips and facts could be separated from the completion advice. Interpreting scores will need to be simplified and further explained.

4. *Add an initial presentation screen.* To ensure that all users read what the program is about and the key buttons they will need to use to help them work through the program, a simple initial help screen should be written.

5. *Improve access to following pages of questions.* Users consistently failed to find the tabs which give access to further pages in each topic area. Another device for page turning needs to be used, or a message to indicate there are more questions or a revised screen layout which makes pages 2, 3 and 4 more visible.

6. *Improve visibility of dials.* The dials are located on a side screen which does not look as if it is part of the main screen. Some users failed to notice the needles moving and only registered the numerical score rising.

7. *Revise all language used on screen.* Many users found terms such as "quit" unfamiliar. However many of these users will be games players and phrases can be borrowed from such programs eg "do you really want to finish this now?"

8. *Enlarge the size of arrow keys or allow direct entry.* Users unfamiliar with a mouse had difficulty using the arrow keys to input their data. Others found this a slow and frustrating way to key in details. Direct entry was strongly sought.

9. *Enlarge the help "?" button.* Users often did not find or use the advice contained. Suggestions for additional help are given under topic headings below.

10. *Check comparative data on energy and transport.* To investigate the occasionally surprising placement of people's scores.

Transport

11. Consider the separate treatment of business and leisure mileage. There was strong resistance to being penalised for business travel.

12. Provide guidance on average fuel consumption for typical vehicles.

13. Provide conversion between money spent on fuel and approximate fuel use.

Energy

14. Re-consider advise on converting quarterly bills to consumption. Where Power cards and Economy Seven are used by households, the conversion factor between cost of energy and amount used will be different from that given to help standard users complete the questionnaire.

15. Provide additional help with interpreting gas and electricity bills.

16. Clarify note on use of oil to ensure this is recognised as heating oil.

17. Provide guidance on treatment of camping gas.

Water

18. Provide advice on calculating hours hose pipe used.

19. Provide for entry of total consumption for metered households.

20. Consider implications of allowing credit to be given for recycling water.

21. Consider additional questions on water used for car washing.

Shopping

22. Provide more assistance with source of food and mode of travel to the UK. Particularly an example shopping list of tinned and packet foods as well as vegetables, with model answer.

23. Provide more assistance with accommodation away from home. Particularly whether this should include, boating holidays, self-catering, hospital visits etc.

24. Provide more assistance with treatment of liquid detergents.

25. Enable percentage purchase of organic food to start below 5%.

House and Garden

26. Provide more assistance with calculating land occupied by home. Including how to treat communal buildings and gardens and odd shaped plots. Wording should be simplified.

27. Provide more assistance with definitions of peat and tropical hardwoods.

28. Consider footprinting of productive garden land. Users were unhappy to be penalised for having large gardens, particularly when these were productive areas of land, used to encourage wildlife or for growing food.

Waste

29. Re-calculating the final waste score. On the paper based, some families added and not subtracted their recycling scores as they had become used to performing a series of additions.

30. Consider an additional question on textile recycling.

31. Provide a note on treatment of the re-use of bulky waste. For households who have disposed of bulk waste by passing it to a friend or organisation.

32. Consider a cross reference to Getting Involved. Users were keen to be provided with information about what they could recycle locally and where their nearest recycling sites were.

33. Look at footprinting of newspapers. To ensure they are not being double counted in purchasing and waste.

34. Check how the algorithm treats items (eg aluminium cans) not recycled because not purchased.

Community Action

35. Provide further advice on what constitutes "community action".

Hints and Tips

36. Re-consider content and order of tips. Users often only looked at the first tip that came up, this needs to be the most engaging one for them to be encouraged to look further. Greater emphasis needs to be given to cost savings available.

37. Link hints and tips to users own score. Users were keen to find out why, when their scores were high and to be presented with ideas for reducing scores.

38. Enable movement backwards and forwards through hints.

Did you know/Fascinating facts

39. *Improve relevance of facts to households.*

40. *Enable movement backwards and forwards through facts.*

Health Information

41. *Improve access to health information.* The red flashing cross was interpreted by users as a signal of their errors.

42. *Improve presentation of health information.* Households were generally interested in health impacts but struggled with the form in which it was presented to them.

Getting Involved

43. *Improve presentation of information.* Users were looking for more information about getting involved and in particular for locally relevant information. National contacts should include addresses for Wales and Scotland.

Report

44. *Improve exit from report screen.*

45. *Enable entire screen to be seen.*

46. *Expand information given in report.* Personalised hints and tips for reducing the overall score need to be presented. The report might also recommend users adopt the actions and test themselves again in six months time. It could suggest that users pass discs on to a friend.

47. *Provide facility to encourage users to experiment.* Users were keen to be guided to look at how change in their actions could alter their scores, perhaps through "50% reduction" buttons which would instantly show the decrease in score from halving their inputs.

Going for Green

48. *Improving content of information supplied about GfG.* Users were not inspired by the initial photographs. No information on GfG is given in the booklet.

ECO CAL MARKET TESTING RESULTS

Comments made by households using EcoCal on

COMPUTER

In the section which follows, the main comments made by households using the EcoCal on computer are given for each community taking part in the testing. In each community, ten households took part, half giving feedback on their use of the computer version.

Needingworth, Huntingdonshire

General Comments

- Easy to use and fun, would like a copy to take home
- Drop down menus allowing choice of unit for response not found
- Help button (under "?") not well used, attention should be drawn to its value
- Direct entry of answers desirable
- EcoCal should specify how the household can move from red to green for each topic
- Report should give more information, especially suggestions for things to do where a score is in the red
- A child's version should be produced with lots of colour and images, asking children about the products they use, waste and litter, walking and cycling and processed food

Transport

- Fuel efficiency of vehicle not known
- Number of miles driven per week very variable, uncomfortable about guessing

Energy

- Bills paid by standing order, consumption not known
- Gas bill not easy to read
- Use of Economy seven not asked about

Water

- Very low scores means there are few steps to take to reduce further, except to cut hose pipe use
- Difficult to estimate hours of hose pipe use

Shopping

- Help information should specify how to treat self catering holidays
- Origins of food very hard to know
- Useful to be made aware of the issue of food miles

House & Garden

- Uncomfortable about being penalised for having a large garden

Waste

- Would like to know more about why plastics recycling is so limited
- Would like information about local recycling facilities
- Would like more information about the paper types it is possible to recycle locally

Getting Involved

- List of addresses alone doesn't encourage getting involved
- Logos beside the addresses would make the information more visually interesting

Health Button

- No-one found the button

St Ives, Huntingdonshire

General Comments

- Program found to be easy to use and interesting to explore
- Feeling of aggrievement that as living in a rural area, high transport scores are inevitable.
- Would like to use a bus, but no service exists, would like a way of recording good intentions
- Help button (marked "?") not used
- Didn't see dials or realise they were changing, only discovered at end
- Space given to dials is small
- Eye focused on number changing but not needle swinging
- Regarded as a guidance tool. Would have liked an option to see easily if eg reduced travel by x%, this would lead to y% reduction in score
- Would have liked more interpretation of score eg "You are a disaster" and for the report to have given hints and tips based on the score
- At home, probably would use the program once only, not keen on computer records and not going to change car use so little point
- May do it with a circle of friends eg in Neighbourhood watch meetings

Transport

- Business air miles make a big difference to the score
- Business stays in hotels are excluded so would like to exclude business mileage
- Differentiating business and pleasure impacts would be helpful
- Running a car gives a very high score. Have to reduce mileage a lot to see score brought down, does not encourage substitution for small journeys.
- Not fair if living a very green lifestyle but overall score biased by car use when this is a necessity

Energy

- Confusion between kWh and units
- Bill itself confusing
- Eastern Electricity only gives units on the bill

Water

- For houses that are metered, an option for direct entry of total use would be helpful

Shopping

- Origins of food very hard to know
- A realistic breakdown would take some effort, would be happy to do this at home
- Trade with rest of world and choice of food is a good thing
- No direct question is asked about locally grown vegetables
- Organic produce is too expensive to buy
- Definition of what should be considered a "luxury" hotel is not clear
- Why does reading a daily newspaper make you an environmental villain?

House & Garden

- Should not be penalised for a large garden if this is productive land
- Option to enter in imperial units should be given
- Tropical hardwoods usually purchased in units of less than $1m^3$
- Guidance on what should be considered "peat" needed, also option to enter cost of bags

Waste

- Frustration at lack of local recycling facilities
- Would like more information about the can types it is possible to recycle locally
- If eg didn't know oil disposal to drain was a problem and acting this way was giving you a large waste score, how could you go back and isolate this action as responsible?

Community Action

- Not clear what constitutes “community” action, advice on whether environmental only needed
- Greater involvement gives a higher score, inconsistent with rest of scoring

“Did you know?”

- Appreciated them when found

Help button “?”

- Generally not seen or used
- More helpful if click on eg peat and be given pictures of different sized bags rather that expect people to press ? button for same help

Hints and Tips

- Only looked at in passing. No real link being made to individual scores.

Health Button

- No-one found the button

St Neots, Huntingdonshire

General Comments

- More background information on the reasons for asking questions would be helpful
- Didn’t notice extra pages - a continuation message for further questions would be good

Transport

- No comments

Energy

- Calculation of total use was a problem

Water

- More useful to measure washing machine use per day (particularly for mothers of younger children)

Shopping

- Unclear as to reason for asking the questions
- More information on the countries of origin needed, with examples

House & Garden

- Considered very hard, in particular the dimensions of houses/gardens
- Some confusion between floors and storeys - number of bedrooms considered easier than storeys;

Waste

- Liked answering the questions on recycling because of the list provided
- Weight of bulk question needs an example given eg sofa, bed

Community Action

- No comments

"Did you know?"

- Considered good

Help button "?"

- Needs to have more information included on them

Hints and Tips

- Considered good

Health Button

- Button missed: possibly better located on bottom part of the screen with the other general information buttons

Report Button

- Inspiring

Kippen, Stirling

General Comments

- Examples use Heathrow and English references
- Button under "?" not recognised as a source of help
- Dials weren't very apparent
- Direct entry of answers desirable
- Further pages of questions not found, help page doesn't include use of tabs

Transport

- No mention of diesel or unleaded fuels
- Business travel counts against you, should be treated separately
- In rural areas there is no choice about car use, should not be penalised
- A question about the availability of public transport should be included so only those choosing not to use it are penalised

Energy

- Couldn't believe score was so high, would be nice to understand why
- Many people's energy scores were off the dial
- Easier to answer LPG question in money and not quantity
- Option to answer oil quantity in gallons as well as litres should be provided

Water

- Odd to be asking questions about watering gardens in Scotland
- No question about water use for washing cars - main use locally

Shopping

- No questions about whether you buy recycled or CFC free products
- Why are newspapers and stays away from home isolated?
- Shopping bills are just about food purchases, why not regular non essentials such as clothes and cosmetics?
- Would be happy to spend more time answering questions about other purchases

House & Garden

- Not clear how to treat communal buildings and gardens

Waste

- No comments

Community Action

- No comments

Help button "?"

- Example of Jack's touring holiday makes him rather sad
- Button only used at the end after guided discovery
- Button not used even when struggling to answer

Hints and Tips

- Some a bit patronising and obvious eg "only buy what you need".
- Some only gave half the facts eg didn't say low energy bulbs cost five times more

Getting Involved

- Addresses need to be relevant for Scotland

Health Button

- Few found the button, those that did, found it at the end and not when flashing
- Information thought to be limited

Report Button

- The whole screen could not be seen
- No clear exit from the report
- Would be nice to know what average scores are, as well as knowing you're better/worse
- Interesting to relate to what is sustainable rather than a comparison against an average

Fallin, Stirling

General Comments

- Would have preferred to have completed it using pen and paper
- Would have enjoyed it more if knew how to use a computer
- Wouldn't use a computer in a library, so probably wouldn't do it again
- Program a good thing for schools
- A bit more colour on the screen would be nice
- More easy questions needed like those for water
- Nothing about pollution asked
- Tabs for further pages of questions hard to find
- Different colours or something which explained what the tabs are would be helpful
- Push button which says "now go to next page" would be better

Transport

- "Average fuel consumption" not understood
- Couldn't calculate distance to Benidorm

Energy

- More help needed in answering questions
- Conversion chart from gallons to litres required for oil question

Water

- Easy to answer

Shopping

- Hard to know what had come by boat or air
- Free papers not included in answers on daily newspapers

House & Garden

- More help needed on calculating areas, also conversion from feet to metres
- Question on hardwood not answered because not understood
- Some examples of types of wood meant would be helpful

Waste

- Deposit return system for glass bottles not catered for in questions

Community Action

- Lighting up the green smileys was nice

Help button "?"

- Didn't use button, didn't think could press on the question mark
- Some just brought up the question again in larger print, thought that was all they did
- Not much help when used, wanted different answers from those provided

Hints and Tips

- Useless
- Quite good
- Could have been more in some of them
- If could tell you where your nearest recycling point was it would be more helpful
- A message to say go and look under local information would be helpful

Did you know?

- A lot of it new so quite interesting

Getting Involved

- Expected more than a list of addresses
- No local contacts so of little interest

Health Button

- Saw it but didn't use it
- When seen flashing thought it meant had done something wrong

Report Button

- Report was nice to have

Eccleston, Lancashire

General Comments

- Quite good
- Would have been easier to find way around if more used to using a computer
- Would have found it helpful to have read the help menu at the start and not the end
- There is potential for it to go into greater detail
- Some questions didn't seem relevant
- Not clear whether "last year" refers to within the last 12 months or during 1996
- Would have liked something to show what happens if eg started to recycle bottles
- Would have liked it to have set a series of challenges, eg put a brick in the cistern this week and see what happens
- When a high score was recorded, it was difficult to go back and find out why
- When inputting numbers using the arrow keys, it was too slow to respond, disincentive to playing around with different settings
- Would be nice to involve children by offering stickers for points which have been taken off the family's total score
- "Need to feel your little bit makes a difference. Need to know not just happening in Lancashire, but all over. That your actions are making a difference."

Transport

- No over-type facility means entry very slow
- Arrows very slow and can't see the numbers going up or down, looks as if nothing is happening
- Guidance would be helpful if distance walked should include walking for pleasure
- Not fair to have such a high score when have to use a car, what about disabled people or those who live in a village

Energy

- Data entry too slow, goes up and down in ones
- Guidance on whether to count camping gas would be helpful

Water

- No question on reducing flushing the toilet or turning off taps

Shopping

- Source of food hard to answer but "made you think"
- Even if at home would probably guess rather than look at labels
- Shouldn't be restricting people to only buying British goods
- Wide range of products available now is good and what's wrong with having strawberries all year round?
- What about support for third world economies?
- Shopping is hard enough already without having to read labels
- If Supermarkets are still going to supply goods, how can you make a difference, you're working against the system
- What is meant by tropical hardwood needs to be explained
- No option given for entering liquid detergent quantities, nothing under help for liquid detergents
- Most people buy little organic food, but automatic count starts at 5%

House & Garden

- If plot of land used to grow vegetables, shouldn't be marked down for it

Waste

- Information about where to recycle things locally would be helpful
- Not fair to be penalised if would like to recycle but can't because of lack of facilities
- Have to say yes/no to each material for recycling, but what if you don't buy any eg aluminium cans? Still penalised for not recycling.

Community Action

- Rewarding to see the green faces light up

Help button "?"

- Too small to be used easily
- Liked the help once found

Hints and Tips

- Fairly obvious
- On a tight budget and already doing all hints and tips for energy, yet still in the red
- Greater emphasis should be given to cost savings available
- A back page facility would be useful to go back and re-read a tip
- Personalised hints and tips would be better

Did you know?

- Looked at a few but not all
- More personal ones were better than the statistics
- The facts should relate to you and your household and not be general

Getting Involved

- Not much information except a list of addresses
- Nothing about what the organisations did was given

Health Button

- Not found

Going for Green Button

- Saw the photographs and didn't look any further
- Thought it was people's life histories

Report Button

- How to leave the report screen is not obvious

Burnley, Lancashire

General Comments

- Interesting
- A good thing
- Quite easy and straightforward to use once you got used to where to press
- A bit confusing to begin with
- Would probably use if in the library, especially having seen it now
- Questions were a bit limited
- Surprised by how much energy used, not aware before
- Program should show how you can save money by reducing use
- Amazing how much water used, not charged for it so don't realise
- Will not change lifestyle "because you have to do things like drive"

Transport

- Information easy to find and fill in
- Train and air mileage difficult to calculate

Energy

- Penalises use of coal too much

Water

- Easy to fill in

Shopping

- Answers given were a bit vague
- Questions a bit hard to understand
- Don't know where goods come from
- Makes you think but probably wouldn't check labels if at home
- Shopping is about personal choice
- If asking about disposal nappies, should be asking about use of cotton nappies as well

House & Garden

- What is the "depth" of your building is too complicated, better to say "length"
- More help needs to be given about what hardwoods are
- Also more help with what is considered to be a "luxury" hotel

Waste

- Not fair to be asked about things not recyclable locally

Community Action

- Liked getting the smiley faces

Help button "?"

- Not used
- Sometimes used, but pressing it a bit scary

Hints and Tips

- Only those for house and garden looked at because of such a high score

Did you know?

- Button not found
- Would have liked to have known about it before starting

Getting Involved

- Not really looked at
- No local information so not of much interest

Help Button

- Would have been useful to have seen at start

Health Button

- Scared to press it in case wiped things off when flashing
- Information leaflet should show what all the buttons mean so you know you are not pressing anything wrong
- Information on pollution would be helpful

Going for Green Button

- Not used

Report Button

- No comments

ECO CAL MARKET TESTING RESULTS

Comments made by households using EcoCal on

PAPER

In the section which follows, the main comments made by households using the EcoCal on paper are given for each community taking part in the testing. In each community, ten households took part, half giving feedback on their use of the paper version.

Needingworth, Huntingdonshire

General Comments

- Questionnaire filled out before looking at handbook
- If information from booklet was part of questionnaire would be better
- Find the information in the booklet useful and interesting now but too late for help with answering questions
- Would have been interesting to have had the "fascinating facts" before hand
- Not enough information on what to do about questionnaire scores
- Hints and tips not really used, better integration with questionnaire would be good

Transport

- Score dominated by business travel, should be able to separate out from family travel
- Treatment of business air travel should be consistent with treatment for business hotel nights

Energy

- Information hard to read from bill
- Consumption not given in kW/h on bill

Water

- No question asked on toilet flushing
- Hose pipe use hard to quantify
- Felt cheated that could not record and be rewarded for specially bought water saving washing machine

Shopping

- Difficult to sort out which food items came from where and how transported
- We're now a global economy, are we encouraging people not to buy tropical fruits
- No where to record free newspapers and junk mail received

House & Garden

- Unclear about why being asked about it
- Gardens felt to be a benefit and should not be penalised

Waste

- Frustrating to be asked about plastic recycling when not available

Community Action

- Not used

Interpreting Scores

- Graphs easy to use

Hints and Tips

- Should emphasise where best to spend effort
- Relative priorities should be clearer, eg so you can see transport very important for you and to stop worrying about where your waste goes
- A checklist of priority actions for you would be helpful

Calculations

- Much better if send away for GfG to carry them out

St Ives, Huntingdonshire

General Comments

- Handbook not really used to help complete questionnaire
- Had information needed so didn't look at the booklet until later
- The front cover could be changed to make it clearer it should be used to help
- References to it in the questionnaire would be helpful

Transport

- Unfair questions when public transport not available
- Occasional, long-haul flights should be averaged over a lifetime or a number of years

Energy

- Easy to fill in when have information to hand

Water

- An option to state total use should be given for people with meters
- A question about chip fat down the drain should be added

Shopping

- For a lot of food it is hard to know its origins, may be the produce of more than one country
- Would be prepared to check labels if had been at home
- Guidance on how to treat boating holidays would be helpful

House & Garden

- A bonus should be given for growing own food

Waste

- Irritation at being asked about recycling plastics when this not possible locally

Community Action

- Not seen
- More guidance on defining community/environmental action would be helpful

Hints and Tips

- Some people didn't use the comparative graphs, just compared their existing actions against hints and tips to see which they were doing already
- Final scores not compared against other households using graph

Fascinating Facts

- Very interesting

Getting Involved

- Not local addresses so not very interesting

Health Information

- Not looked at

St Neots, Huntingdonshire

General Comments

- All of it useful
- Appeared a little complicated at first, but fine once in the swing
- Layout of questionnaire easy enough to follow but maths too hard
- Better to score on a points system rather than have to do the maths
- Use of decimal places too hard and unfamiliar with using a calculator
- Didn't use the booklet when filling out the form and wished had used it more
- If had booklet at home, would read it

Transport

- Not a driver, so hard to complete
- Calculations OK once explained
- Never worked in kilometres before, but used conversion chart

Energy

- Booklet note did not help interpret question on heating oil, could be taken to mean cooking oil
- Heating bills not kept as pay monthly in advance, so hard to find information
- Told once a year only what reading is

Water

- Straightforward to answer
- Hard to estimate hose pipe use

Shopping

- Found example of newspaper calculation hard to follow, should include Saturday too
- Very difficult to know where food is from
- Shop daily for meat and bread so hard to total for week

House & Garden

- More guidance needed on answering size question, eg front garden or back garden
- Wording should be changed to make clearer eg "edge to edge"
- Hardwood is not a familiar term, some guidance would be helpful

Waste

- No recycling facilities, but didn't mind being asked about it
- Would like to have answered a question on re-using carrier bags as people often discard them

Community Action

- Did find smiley faces in booklet

Interpreting the Score

- Good and interesting to use charts
- A bit tricky to use at first and had to be explained

Hints and Tips

- Some good hints in booklet which hadn't thought of before
- Now going to try low energy light bulbs
- Taking recycling when shopping and taking used carrier bags new ideas to try

Fascinating Facts

- Good
- Not of interest

Getting Involved

- No comments

Health Information

- Not seen
- Found, but not of interest
- Found, but not thought to be of relevance, so not read

Kippen, Stirling

General Comments

- Relatively easy to follow and well laid out
- Calculations easy to follow and well structured
- Handbook only skimmed
- Notes for completing the questionnaire were more helpful than the hints and the fascinating facts
- Felt had a low overall score but still could do very much more

Transport

- Money spent on petrol known but not number of litres used
- A conversion chart from £ to litres would be helpful
- Otherwise straightforward

Energy

- Calculations OK

Water

- Straightforward

Shopping

- Hard to know so estimates given
- Country of origin not really thought about before
- Buy what need and not according to where it has come from
- Some things are the produce of more than one country
- When buying Kellogg's cereals eg, how do you know the source of the grain?
- If completing at home, would be willing to check labels in cupboards

House & Garden

- Irregular plot shape is hard to calculate
- Guidance about conversion between distances and number of paces would be helpful

Waste

- Happy with calculations

Community Action

- Didn't bother to award green smileys

Interpreting the Score

- Not done as too difficult
- Score not on scale so may have calculated wrongly
- Not very interested in comparisons with other households
- Like to do a yearly comparison of own score

Hints and Tips

- Generally OK
- Pretty self evident
- Shopping hints were new

Fascinating Facts

- No comments

Getting Involved

- Organisations listed didn't include Scottish contacts
- Local contacts would be helpful

Health Information

- No comments

Fallin, Stirling

General Comments

- Interesting, helped to think about the environment more
- Food for thought
- Shows you how much waste you are producing - "I need to cut down on waste"
- Calculations layout complicated, OK once got started
- Metric and using a calculator difficult
- Conversion tables hard to use

Transport

- Guidance looked for over whether if regularly car share, a proportion of petrol used should be counted
- Difficult to work out walking distances, useful to give guidance on average distance walked in eg 10 minutes

Energy

- Booklet to include advice on converting £ spend to kWh would be helpful
- Worried about size of energy bill, found hints and tips useful
- Thought that turning things on and off used up more energy

Water

- Questions OK

Shopping

- Very difficult to know where things come from
- Don't ever buy the things included on the example list
- Buy tinned stuff and packets and these should be given as examples
- Examples of things transported by sea would be helpful
- Also a sample shopping list with details of where they're from and how they arrived

House & Garden

- Calculating the size of the hose is very hard
- Would have measured it if had been at home
- Not clear what to do as live in a communal block in sheltered housing

Waste

- Recycling is a problem without a car

Community Action

- Not used

Interpreting the Score

- Graphs not well used or understood
- Scores thought to be off scale

Hints and Tips

- Didn't tell you where your shopping came from

Fascinating Facts

- Not really looked at

Getting Involved

- Not used

Health Information

- "Too many big words" in health impacts
- Not of very much interest

Eccleston, Lancashire

General Comments

- Tricky to start with but not too bad once got used to it
- Straightforward once got into flow
- Difficult after a long day
- Indigestible and off-putting
- Calculations difficult, also converting between imperial and metric units hard
- Brings out implications of what you do at home, makes you think about things
- Frustrated by lack of being able to do anything about transport use - so not motivating
- Only read the notes when couldn't answer the question, then was helpful
- Didn't use booklet
- Helpful notes for completion should be put beside questions

Transport

- If you have a job with a lot of travel, you are unstuck from the word go
- Should be able to differentiate between business and leisure travel
- Sometimes difficult to split business and pleasure miles, may be difficult to answer separately
- Heavily penalised for using any form of transport
- Not a lot you can do to reduce car mileage if you drive for work
- A question to see if you have thought about lift sharing would be good

Energy

- OK

Water

- Would be good to add a question on water used for washing cars
- Wanted to be asked a question about how much water was collected and recycled - "wanted brownie points for using a water butt"

Shopping

- Very difficult to know where things come from or how they travel eg cheeses
- Wouldn't spend time at home checking labels
- Didn't use booklet to check
- Suggest add hospital nights to hotel nights
- Maybe use alternative wording: " nights away from home in other accommodation"
- Maths for question 23b and 23c difficult to follow, perhaps would be clearer if all on one line

House & Garden

- Calculating size of plot took a long time, mistake made converting between feet and metres
- Question should be worded using "width and length", not "depth"
- Before being penalised for having land, it should take into account what you are doing with that land
- Unclear about whether compost used contains peat or not, more guidance needed
- Hardwood needs further guidance also

Waste

- OK
- Why not ask how much used oil is recycled, to be consistent with other questions
- Did not like being asked about plastics recycling because not possible
- Wanted to answer a question about the amount of excess packaging they bought
- No-one went to hints and tips to see if anything about it in there

Community Action

- Not clear how to interpret environmental or other community work

Interpreting the Score

- Graphs not easy to use
- Had to be shown that scale was in 100s
- Only compared final scores and not for each subject

Hints and Tips

- Hints and tips should be taken out and put in an appendix, only wanted to see the information needed to complete the questionnaire until ready for more
- Knew a lot of hints and tips already
- Wasn't interested in hints and tips until the end

Fascinating Facts

- No comment

Getting Involved

- No comments

Health Information

- No comments

Burnley, Lancashire

General Comments

- Very interesting
- Should be advertised more
- Enjoyed doing it but found it a bit hard with calculating distances and house size
- Booklet helpful

Transport

- Planes and trains not relevant

Energy

- Easier to answer in money spent than kWh

Water

- OK

Shopping

- Confusing but thought provoking

House & Garden

- Measurements difficult

Waste

- Frustrating that couldn't recycle locally
- Strong feeling that they could do something to waste score if only Council started a collection scheme

Community Action

- Not completed but found faces pleasing

Interpreting the Score

- Graphs not understood

Hints and Tips

- No comments

Fascinating Facts

- Mildly interesting

REPORT ON PROBLEMS WITH ECO-CAL

Compiled by I.T. Services Department

Problems incurred

- The Eco-Cal software appears to install without problems when using WINDOWS '95. It will warn the user that all applications, particularly Microsoft Office, must be closed down before installation begins. If this is not done, the PC halts the installation. However, in earlier versions of WINDOWS, e.g. 3.1 and 3.11 no such warning is given. In this case, when the Eco-Cal software is installed, the DYNAMIC LINK LIBRARY files are over written instead of being upgraded, which is what is meant to happen.
- It is not very WINDOWS compliant. For example, the user cannot tab in sequence, or write free text, or overtype in any of the boxes.
- The HELP function is not very helpful.
- Problems are experienced when removing the Eco-Cal software from PC's. On some machines Microsoft Office DYNAMIC LINK LIBRARY files are deleted when Eco-Cal is removed.
- No instructions have been given in the Information pack that comes with Eco-Cal on how to remove the software from a PC. Clear instructions **MUST** be given.

Group PC's affected

REGION	**PC AFFECTED**	**PROBLEM**	**SOLUTION**
East Anglia (Nigel Dark)	Viglen 486 Running Windows 3.1	MS Office Dynamic Link Library files overwritten. Once Eco-Cal had been loaded couldn't use MS Office Package	Tried just re installing MS Office, problem still occurred. Had to re format Hard Disk and re load DOS and Windows 3.1
	Dell 486 Running Windows 3.1	(Same as above) Also, some of DOS files were overwritten	(As above)
Midlands	Anita 386 Running Windows 3.1	MS Office Dynamic Link Library files overwritten. Once Eco-Cal had been loaded couldn't use MS Office Package	Tried just re installing MS Office, problem still occurred. Had to re format Hard Disk and re load DOS and Windows 3.1
Communications (Ginettes PC)	Compaq Pentium PC running Windows 95	Removed Eco-Cal – then couldn't get into MS Word	Re installed MS Office
North West (Dave Smith's Home PC)	486 PC	Application error on his machine as Dynamic Link Library files had been overwritten	David sorted out the problem himself by re-loading his software