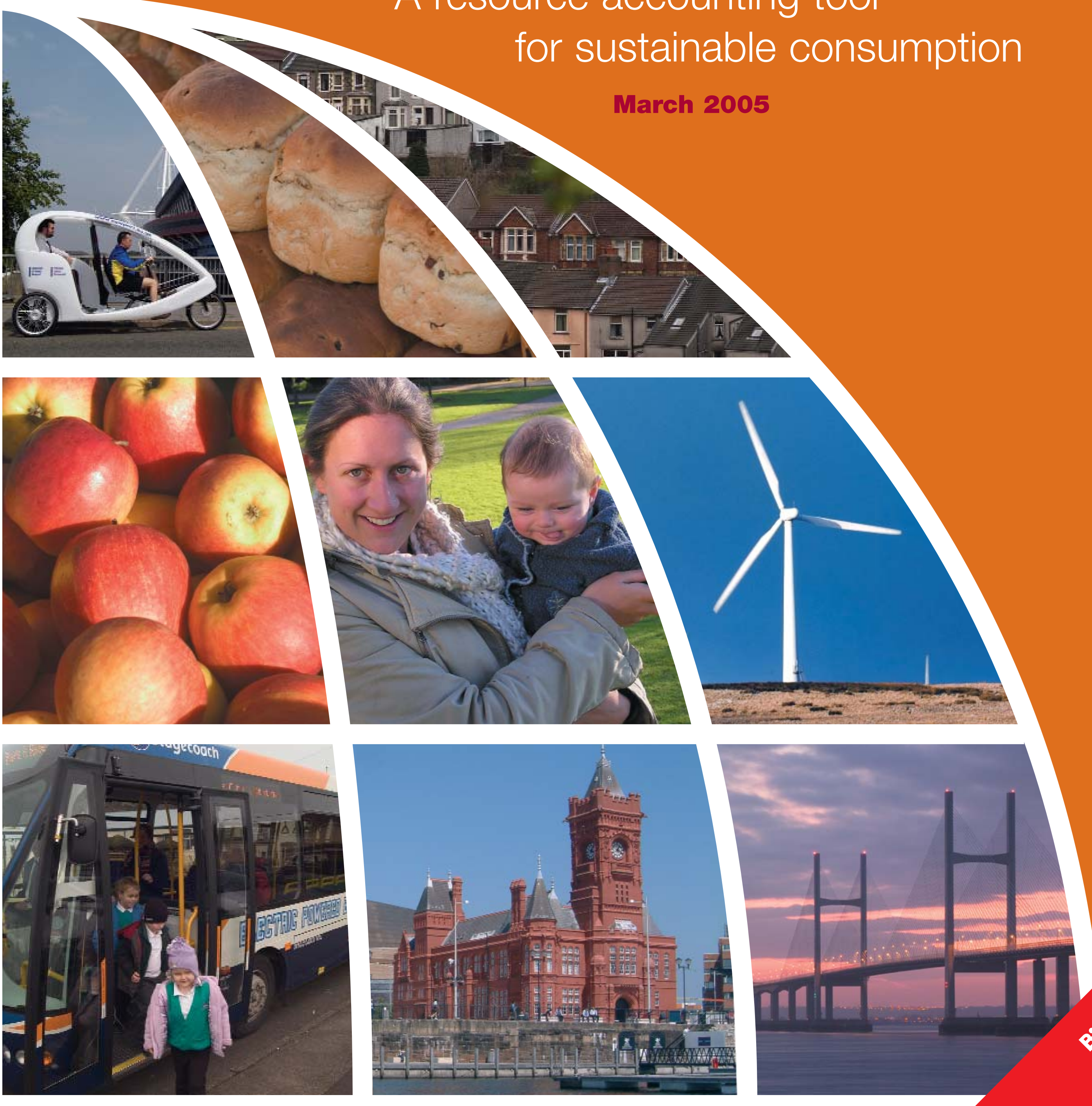
Reducing Wales' Ecological Footprint

A resource accounting tool
for sustainable consumption

March 2005



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1. Sustainable Development in Wales – An Introduction to the Project

1.1 Sustainable Development and the Ecological Footprint in Wales

The need for humanity to live within environmental limits is the underlying message of most definitions of sustainable development. A simple concept, in theory, but when it comes to putting sustainable development into practice we are immediately swathed by confusion and conflict. This has undoubtedly slowed progress toward achieving sustainable development.

Achieving sustainability in Wales is high on the current governmental agenda. In order to assess whether Welsh society is any closer to achieving sustainability, the Welsh Assembly Government (WAG) have identified a series of indicators that will be used to monitor their progress.[1] Included in this list is the Ecological Footprint, the focus of this very study, making the Welsh Assembly Government the first administration in the world to use the Ecological Footprint indicator as a tool to measure real progress. The eight chapters that make up this report have looked, in detail, at some of the various policies and targets that have been established by WAG across the different sectors of society in an attempt to achieve sustainability. By applying the Ecological Footprint, along with other indicators, we have been able to quantify the materials and resources which have been consumed within Wales, along with their associated wastes, and have answered one main question: Is Wales currently sustainable? Following this we go on to explore whether current policies and strategies will, in the future, bring Wales any closer to achieving this sustainability goal.

However, the Ecological Footprint only takes into account one of the many dimensions, which comprise sustainable development – ecological sustainability. Other dimensions such as quality of life are as important as ecological needs, in fact they are all inextricably linked. However, for the purpose of this study we have isolated the ecological aspect and explored it with the use of the Ecological Footprint to provide you with an in depth analysis of the potential of the Ecological Footprint as a sustainability indicator.

[1] National Assembly for Wales (2004) Sustainable Development Indicators for Wales 2004, Statistical Bulletin 18/2004; http://www.wales.gov.uk/keypubstatisticsforwalesheadline/content/sustainable/2004/hdw20040323-e.htm

1.2 Sustainable Development Policies in Wales

The National Assembly for Wales has a duty under section 121 of the Government of Wales Act 1998 to promote sustainable development in the exercise of its functions.[2] Under the Act the Assembly is required to set out a scheme proposing how it plans to implement the duty. The first Sustainable Development Scheme was subsequently adopted in 2000 by the Assembly in plenary and has since undergone review and been superseded by the latest scheme 'Starting to Live Differently' (2004). The scheme sets out the vision of a sustainable future for all of Wales where action for social, economic, and environmental improvement work together to create positive change.[1] Included in the scheme's umbrella to deliver change are three key documents:

1. 'Sustainable Development Action Plan' (2004) of the Welsh Assembly Government identifies the major long-term strategic challenges for Wales in delivering that vision and identifies the key actions that need to be taken in the short, medium and longer term for the period 2004-2007.
2. 'Wales: A Better Country' (2003) sets out the Welsh Assembly Government's political priorities against the vision of a sustainable Wales, for the next four years.
3. The 'Wales Spatial Plan' (2003) recognises that the vision will need to be translated differently in different areas of Wales. The Plan, still under the consultation phase, provides both the opportunity for dialogue between the national and local levels about what is needed in those areas and the tool for delivering those agreed needs into action.

1.2.1 KEY POLICY OBJECTIVES AND TARGETS

The notion of Sustainable Development is embedded in the numerous WAG strategies that address specific areas of Welsh society. These strategies have been thoughtfully developed to sit beneath the core Sustainable Development framework, their role being to underpin the delivery of a sustainable Wales. Table 1 below lists a number of such strategies.

[2] National Assembly for Wales (2004), Starting to Live Differently: The Sustainable Development Scheme of the National Assembly for Wales

Table 1: Key themes and strategies implemented by WAG

Food production and consumption: ▪ Farming for the Future: A new direction for Farming in Wales (2001) Welsh Assembly Government ▪ Food and Well Being: Reducing inequalities through a nutrition strategy for Wales (2003) Food Standards Agency & Welsh Assembly Government ▪ Second Organic Action Plan for Wales 2005-2010 (2004) Agri-Food Partnership Organic Strategy Group
Energy production and consumption: ▪ Review of Energy Policy in Wales: Part 1 Renewable Energy and Part 2 Energy Efficiency (2002) Economic Development Committee, National Assembly for Wales ▪ Warm Homes and Energy Conservation Act 2000: A fuel poverty commitment for Wales (2003) Welsh Assembly Government ▪ Facilitating Planning for Renewable Energy in Wales: Meeting the Target - ARUP Final Report of August 2004 ▪ WAG's Economic Development Minister's Energy Statement (2003) Davies, A.
Transport: ▪ Trunk Road Forward Programme (2002) Welsh Assembly Government ▪ The Transport Framework for Wales (2001) Welsh Assembly Government ▪ Intra-Wales Scheduled Air Service: A Consultation Document (2004) Welsh Assembly Government
Built Environment: ▪ Starting to Construct Differently: Action Plan for the Construction Industry in Wales (2004) Constructing Excellence in Wales and WDA Cardiff University Mandix.
Waste: ▪ Wise about Waste: the National Waste Strategy for Wales (2002) Welsh Assembly Government

In the following chapters of this study we go on to explore, in detail, some of the issues and methods employed in the key themes and strategies outlined in Table 1. Each chapter is designed with the aim to:

1. unravel the inherent tensions between society, the economy and the environment to highlight areas where the Sustainable Development scheme complements and supports the key aims in each of the strategies listed in Table 1, and where, inevitably, conflict prevails.
2. explore the effectiveness of the strategies adopted to bring about a positive change in sustainability within the context of the Ecological Footprint.

1.3 Project background

1.3.1 WHAT IS THE ECOLOGICAL FOOTPRINT?

With more than six billion people living on the planet, there is an ever-increasing need for us to understand how much of the planet's natural resources we have got to share between us. The Ecological Footprint is one way to measure the environmental burden of our lifestyle.

The Footprint calculates how much productive land and sea is needed to provide us with the energy, food and materials we use in our everyday lives. It also calculates the emissions generated from the oil, coal and gas we burn, and it determines how much land is required to absorb these emissions. The Ecological Footprint can be applied to a product, individual, household, school, business, city, region or country. It allows us to see who is over-consuming and taking more than the average share of the Earth's resources – and, at the other end of the scale, who's not getting enough.

If each person had an average share of all the productive land and sea available on the planet, it would work out at about two hectares for each of us. However, the average Welsh person uses over five global hectares of resources and if present global trends go unchecked, the human population would need three Earth-sized planets to sustain our current consumption patterns.

How can schools, businesses and governments be more efficient in their use of resources? What can individuals do to help, and how can we start to reduce our impact on the planet? How can we use renewable energy to make Wales a sustainable country? These are just a few of the many questions that the Reducing Wales' Footprint project set out to address.

As outline in the section above, the National Assembly for Wales has a legal duty to promote sustainable development – development which meets the needs of people today without compromising those of future generations – in all that it does. It has chosen to adopt the Ecological; Footprint as an indictor to measure how sustainable Wales is... or isn't, as the case may be.

1.3.2 WHY IS THE FOOTPRINT SUCH AN IMPORTANT INDICATOR TO CONSIDER IN WALES?

The issue of sustainable consumption has become one of the most challenging concepts we face today. There is concern that the present indicators used to address sustainability do not provide the information required to understand the issue. The Ecological Footprint has been identified as a potential solution to this problem by providing information on the global impacts of consumption as well as creating a clear understanding of environmental limits.

Measuring Ecological Overshoot

Sustainability requires living within the regenerative capacity of the environment. As the Ecological Footprint measures the amount of land we need to support our lifestyles we can use it to assess the demand we are placing on the environment. In present times, according to the latest Ecological Footprint analysis, human demand is exceeding the biospheres regenerative capacity by about 20% and hence we are in 'ecological overshoot' (see Figure 1).[3]

[3] Living Planet Report 2004, World-Wide Fund for Nature International (WWF), Global Footprint Network, UNEP World Conservation Monitoring Centre. WWF, Gland, Switzerland. http://www.panda.org/livingplanet

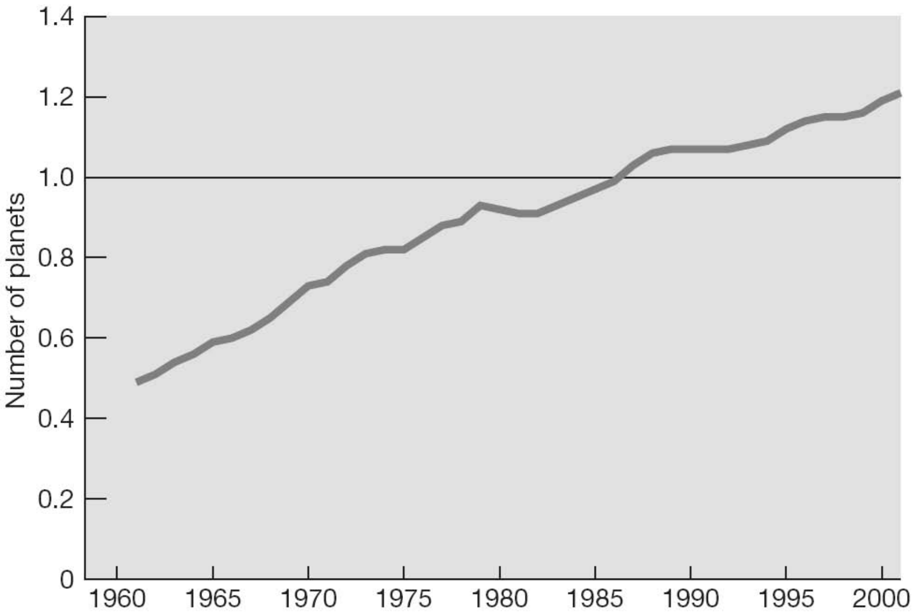

Figure 1: Humanity's Ecological Footprint, 1961-2001 (adopted from the Living Planet Report 2004)

This is a very important and significant concept to understand as ecological limits are difficult to detect and the consequences are time delayed. For this reason it is actually possible to use natural capital faster than it can be replenished and hence natural stocks can be depleted without immediate consequences. For example you can over-fish a local area so that the population cannot regenerate year after year, inducing instability into the system until eventually there is a crash in the population. This may either take years to recover or may result in localised extinction of the once abundant fish stock.

For a governmental body to truly address the issues of sustainable development it is imperative that the notion of living on a planet with **ecological limits** is accepted. It is not possible to be sustainable if in one year we are drawing on ecological services faster than they can be replenished. In essence, ecological overshoot means the overuse of domestic or overseas land resulting in overgrazed pastures, depleted fisheries, degraded forests, and the accumulation of carbon emissions in the global atmosphere. The Ecological Footprint is an important tool in attempting to understand this phenomenon.

Overseas Impact

The environmental impacts of consumption is not only felt by the people who are consuming, but often also have indirect impacts on people in other parts of the world. For example, it is the industrialised world that disproportionately emit a large amount of greenhouse gases, however it is the poorer countries who cannot afford to adapt to climate change who are feeling the consequences. Many of the headline sustainability indicators and Sustainable Consumption indicators also ignore these issues. They are generally related to domestic consumption and production or "local" environmental impacts and do not take into account the environmental impacts in other countries that are created as a result of our actions on the other side of the world (for example, the emissions from a Chinese factory that produces the hi-fi in our living room). The Ecological Footprint overcomes these issues by calculating an individual's impact independently of where that impact is occurring.

There is the danger that the current indicators show a decoupling that takes place only within the national boundaries. Thus someone might think that the trend is towards sustainability whereas in fact unsustainable production processes and emissions have merely been "exported". International trade, for example, has an impact on national CO_2 emissions and consequently on the ability to fulfil national CO_2 reduction targets. Through goods and services traded in a globally interdependent world, the consumption in each country is linked to greenhouse gas emissions in other countries. It has been argued that in order to achieve equitable reduction targets, international trade has to be taken into account when assessing a nations' responsibility for abating climate change. Therefore, in alternative to the principle of ‘territorial’ or ‘producer responsibility’ the principle of ‘consumer responsibility’ has been proposed in order to suggest more efficacious and fair policies, mainly distinguishing between. The Ecological Footprint follows this principle.

1.3.3 REDUCING WALES’ FOOTPRINT PROJECT

The project “Reducing Wales’ Footprint” provides a comprehensive framework for some of the fundamental factors of sustainability at the regional and sub-regional scale. The research is based on analysis of the flows of materials and energy through Wales, Cardiff and Gwynedd, and the associated environmental impacts at both local and global scales.

The principal methods used are a Material Flow Analysis (MFA), Ecological Footprint analysis (EF), and a scenario framework:

- MFA takes a cross cutting view on all physical activity in the region.
- The EF approach brings together key environmental burdens, by expressing each in the common denominators of material flow, energy flow and their land-use demands.
- The scenario approach then extends present day information to a future perspective, in order to relate to the problems and opportunities of stakeholders.

The project brought together a wide range of partners including WWF Cymru, Cardiff Council and Gwynedd Council, Cardiff University and Bangor University, Stockholm Environment Institute (York), Welsh Assembly Government, and several Assembly Sponsored Public Bodies (ASPBs) including the Countryside Council for Wales, Environment Agency for Wales and the Welsh Development Agency (for more information please visit the project website: http://www.walesfootprint.org).

The three main bodies carrying out research were:

- Stockholm Environment Institute at York (SEI)
- BRASS, The Centre for Business Relationships, Accountability, Sustainability & Society at Cardiff University
- Institute of Environmental Science, University of Wales, Bangor

To calculate the Ecological Footprint for each area, data has been collected on household expenditure, transport, food, energy, housing and waste. The level of impact that each person living in Wales, Cardiff and Gwynedd has with each component determines the size of each area's Footprint.

The Footprints of Wales, Cardiff and Gwynedd were presented to the Welsh Assembly Government, Cardiff Council and Gwynedd Council in 2005. The reports will be used to inform policy and practice within the Assembly and the Councils. They will also be used as a tool for raising public awareness of the lifestyle choices we all make and the impacts these have on the size of our Footprint.

During the course of the project the basis was laid for the software programme REAP ('Resources and Energy Analysis Programme') which SEI York is currently developing. All the calculations and scenario modelling was performed with the first spreadsheet version of REAP. Further development during the 'Ecological Budget UK' project will produce a user-friendly software interface with built-in scenarios that can be customised by the end user.

1.4 Structure of the report

This report contains details of the Ecological Footprint for Wales. The reports for Cardiff and Gwynedd are being produced separately by Cardiff University and University of Wales (Bangor), respectively. This report consists of eight chapters and one appendix, each of which is independent and can stand alone as a separate report. It is thus possible to determine which sections are relevant to the reader.

This introductory chapter is followed by the overall results of the project in Chapter 2. The remaining six chapters delve into the separate policy areas. For each of these six chapters a look is first taken at the Ecological Footprint and Material Flow Analysis results. This is followed by a policy appraisal and links are made to how this could potentially influence Wales' global environmental impact. Finally, the bulk of the chapters consist of scenario modelling and projections into the future to determine how the Ecological Footprint of Wales will change if the current policies in place are to be achieved. The appendix to this report includes a detailed technical description of the methodology employed. Table 2 clearly details the content of each chapter.

Table 2: The structure of the full project report "Reducing Wales' Footprint"

Chapter Number	Contents
Chapter 1	Introduction to the Project
Chapter 2	Overall Results
Chapter 3	Food
Chapter 4	Energy
Chapter 5	Transport
Chapter 6	Built Environment
Chapter 7	Waste Management
Chapter 8	Sustainable Consumption
Appendix	Methodology

To ensure the policy relevance of the report a number of key steps have been taken. These being:

- The formulation of a project steering group, put together and administered by WWF-Cymru, who have successfully engaged key stakeholders in the field of sustainability.
- Constant dialogue with the Welsh Assembly Government. For Chapters 3 to 7 a "Policy Expert" was identified within the WAG. Initial communication ensured that the most recent data, publications and policies were being used or highlighted in this report. Secondly, a constant

exchange and checking and verification of data has occurred throughout the project. Thirdly, all the scenario results have been shared with the "policy experts". We have ensured that we had enough time to respond to their comments. We have greatly valued the feedback we have received. For the scenarios, specific questions have been posed to the "Policy Experts". These being:

- Have the scenarios generated captured the main policy concerns associated with the statement on … policy in Wales?
- Are the scenarios reasonable and reflective of current policy initiatives?
- What key issues would you like to see raised in the discussion section which follows the results generated from the scenarios?

In conclusion, we hope you find the report useful and relevant to the sustainability debate in Wales.

2. Overall Results

2.1 Introduction

The overall results and a broad analysis have been presented in this section, however the following chapters focus on specific policy areas, including food, energy, household consumption, built environment, transport, and waste. This is useful in terms of organising and reporting the findings and in terms of informing Welsh policy. From the social perspective the use of Footprinting is perhaps most useful as an input to a wider discussion on quality of life and the social processes which may enhance it. The Footprint results help raise awareness and provide a useful conceptual tool to explore consumption choices. For a detailed technical description of the methodology please refer to the appendix to this report.

The Ecological Footprint captures the resource use and impacts on the environment that Welsh residents generate via their direct consumption. This consumption may include goods or services produced or provided in the region, or outside the region and then imported. Their environmental impacts may be anywhere in the world. Meanwhile there are many industries in the region that export some or most of their production; for these industries, only the part that is consumed in the region is accounted for in this study.

2.2 Concepts of Ecological Footprints and Material Flow Analysis

There is a limited amount of productive land on the planet to provide for all humanity's needs and wants. Sustainable development requires that we live within the carrying capacity of the earth, allowing our economies to develop while ensuring that basic human needs such as food, clean water, shelter and warmth are provided for everyone. This is becoming increasingly difficult due to population increases, and it is exacerbated by the inequalities that exist between rich and poor nations. The World Watch Institute (WWI) have estimated that the 12% of the world's population living in North America and Western Europe consume over 60% of global resources (WWI, 2004)[4].

Box 1: The two components of the Ecological Footprint

Land footprint: The land footprint includes the area required to produce all the crops, the grazing land required to provide meat consumption, the forest land required to produce forest products and the fishing ground required to produce the fish and seafood products consumed by people living in a defined area.

Energy footprint: An energy footprint represents the area required to sustain energy consumption. This includes the energy used directly by households and services in the region and the indirect energy to produce goods imported and consumed within the region. The footprint is calculated as the area of forest that would be required to absorb the resulting carbon dioxide emissions, excluding the proportion that is absorbed by the oceans.

[4] World Watch Institute (2004) State of the World 2004 (special focus on 'The Consumer Society'), Washington DC.

The **Ecological Footprint** (EF) has been developed as a combined measure of total environmental impact (similar to GDP – Gross Domestic Product – in economic terms). The EF is based on the area of land need to provide raw materials and crops, and to absorb pollution and waste, from consumption in a given area. The EF is measured in a standardised area unit equivalent to a world average productive hectare or 'global hectare' (gha), and is usually expressed as global hectares per person to permit comparisons between countries or regions (unit 'global hectares per capita' or gha/cap). The numbers always refer to one year. Often the Ecological Footprint is divided into **'land footprint'** and **'energy footprint'** (see Box). The benefit of the EF approach is that it assesses the impact of consumption from a consumer perspective, i.e. it takes into account the impact of the residents within a defined boundary rather than the industries located there.

Globally, the average Ecological Footprint per person was 2.2 gha/cap in 2001 (the most recent year for which data has been calculated; WWF, 2004)[5]. This demand on nature can be compared with the Earth's biocapacity, based on its biologically productive area – an average of 1.8 global hectares per person (excluding biodiversity considerations). This means that humanity's Ecological Footprint in 2001 exceeded global biocapacity by 0.4 gha/cap, or 21 per cent, suggesting that humanity is using more natural resources than can be sustained in the long term. If the world's total population were to live at the level of affluence of the UK, i.e. at 5.4 gha/cap (WWF, 2004), we would need 3 planets to sustain this lifestyle.

A complementary approach to the EF method is an assessment of resource flows within a defined boundary, termed a **Material Flow Analysis**. This looks at the material inputs to a region in terms of raw materials and products, at the trade balance and at the outputs in terms of waste and emissions, plus any changes in stocks. The analysis concentrates on the consumption of goods and services by households and the commercial sector, including materials directly used and consumed, but also indirect material flows associated with upstream industrial production processes, including wastes and energy carriers used for extracting, transporting and producing materials.

As a result of these two analyses three of main physical indicators have been generated:

- **Ecological Footprints** (EF), measured in global hectares per capita,
- **Material flows** of production and consumption, measured in thousands of tonnes,
- **Carbon dioxide** (CO_2) **emissions** as the largest single cause of climate change, measured in tonnes per capita.

These indicators help to understand and measure the environmental pressures caused by consumption. Collaboratively they provide a comprehensive indicator for ecological sustainability, enabling us to determine whether we are living within the capacity of the earth's biosphere to regenerate itself, or if we are depleting the stocks of natural capital on which we depend.

For a more detailed description of the methodologies employed in this project please refer to the appendix to this report.

[5] WWF (2004) Living Planet Report 2004

2.3 Results

In this section the overall results are discussed under the sub headings of Ecological Footprint, Material flow Analysis and carbon dioxide emissions. It must be noted that the results can be broken down and looked at in any number of different ways. The categories chosen here are those that the authors perceive to be the most useful however this is not necessarily the most useful breakdown for other users. The full results are shown in the appendix at the end of this chapter. Please feel free to recombine the results in a manner that suits your own specific interests and create your own subcategories.

2.3.1 THE ECOLOGICAL FOOTPRINT

The overall Ecological Footprint of Wales in 2001 was 15.2 million global hectares (gha). This is over 7 times the actual land area of Wales (2.1 million hectares). Although these two numbers are not directly comparable their magnitude shows clearly that a greater land area is required to satisfy the demands of consumption in Wales than is available within the boundaries of the country. On a per capita basis the Ecological Footprint is 5.25 gha/cap, which is slightly lower than the EF of a typical UK resident (5.35 gha/cap). Despite this, when compared to the available global capacity of 1.8 gha per person, we can see that if all the world's population were to live like the average Welsh resident we would need almost three planets to sustain this level of resource consumption. The results are summarised below in Figure 2 and Table 3.

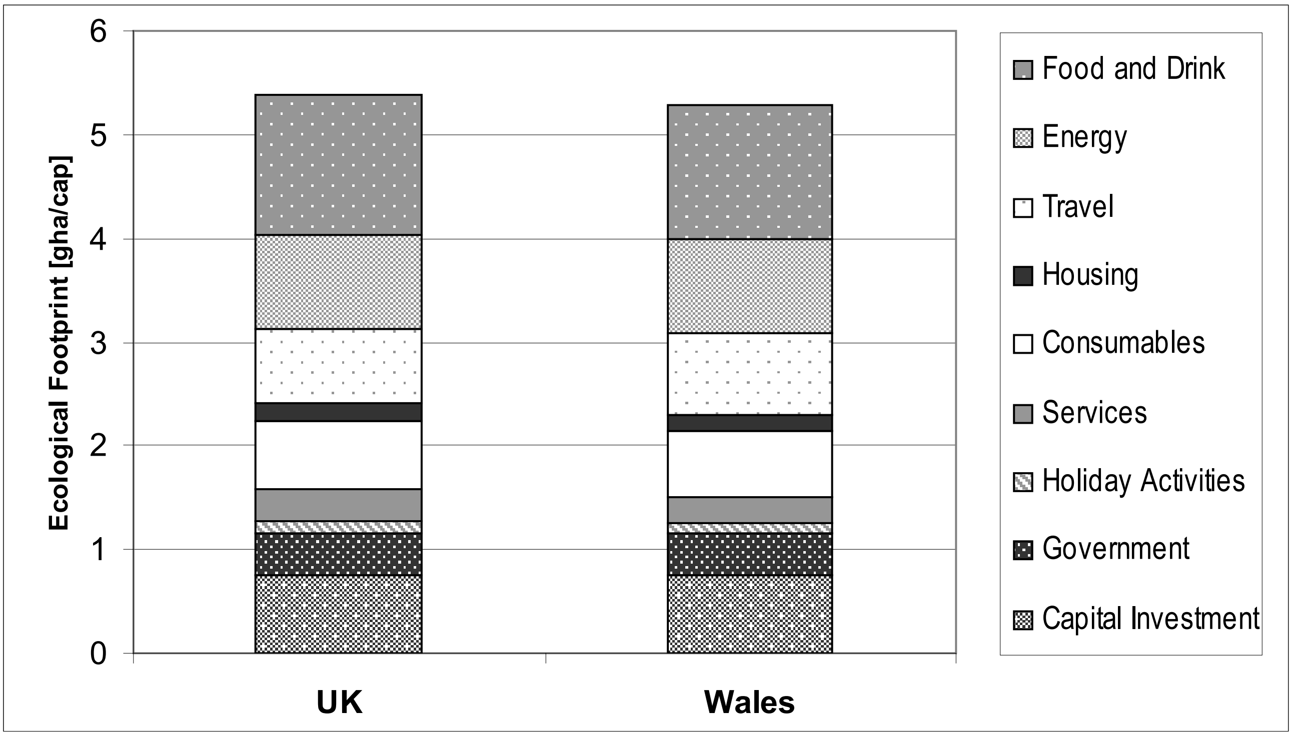

Figure 2: The Total Ecological Footprint of the UK and Wales

Table 3: Comparison of the Ecological Footprints of the UK and Wales for the year 2001

	UK gha/cap	**Wales** gha/cap
Food and Drink [a)]	1.34	1.29
Energy	0.90	0.92
Travel [b)]	0.73	0.78
Housing	0.18	0.17
Consumables	0.65	0.64
Services	0.32	0.24
Holidays abroad	0.12	0.10
Capital Investment [c)]	0.74	0.74
Government [d)]	0.41	0.41
Other [e)]	-0.03	-0.03
Total	**5.35**	**5.25**

a) includes catering services
b) includes transport services and air travel
c) Capital Investment or Gross Fixed Capital Formation (GFCF): Relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment, dwellings and other buildings and structures. However, it also includes investment in intangible fixed assets, improvements to land and also the costs associated with the transfer of assets. The investment relates to assets which are used repeatedly in the production process for more than one year and as such covers such purchases as: software, mineral exploration and purchases of dairy cattle. The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.
d) Includes central and local government. The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.
e) includes non-profit institutions serving households, valuables, changes in inventories and overseas tourists in the UK; the latter one leading to an overall negative Footprint.

Both Figure 2 and Table 3 reveal that the Ecological Footprint for the UK and Wales are fairly similar. When considered this is not too surprising as an average individual living in Wales would tend to consume fairly similarly to an average UK resident (for example they may both drive a Ford Focus, shop in Sainsbury's and go on holiday by plane once every year). Where the real differences lie is when a look is taken at the consumption patterns of different socio economic groups. This topic has been discussed in detail in Chapter 8 of this report. Although the overall Ecological Footprint results are of definite interest, the real value come when they are used to assess policy and a look is taken at how we can actually influence these numbers.

Although the results are very similar there are some differences that can be observed. The most significant being in the service sector where the Ecological Footprint in Wales lies some 23% below that of the UK. For the categories of food and drink consumption, housing, holiday activities and consumables the Ecological Footprint in Wales is below that of the UK. However for the categories of energy and travel Wales has a greater impact per resident than in the UK. For the remaining categories, capital investment, government and other, the footprint is equal for Wales and the UK. This is due to the fact that these categories represent impacts that are shared between all residents of the UK, i.e. there is a shared responsibility.

In both Wales and the UK, food production, supply and consumption is the single highest component of the total Ecological Footprint at 1.29 and 1.34 gha per person respectively. Other components with high Ecological Footprints are energy consumption (0.92 and 0.90 gha/cap), transportation (0.78 and 0.73 gha/cap) and capital investment. Capital Investment or Gross Fixed Capital Formation (GFCF) relates principally to investment in plant and machinery, transport equipment, dwellings and other buildings and structures. It basically represents the public and industrial infrastructure that is shared amongst all UK residents.

Land types

The Ecological Footprint can be broken down into six different land types, these being bioproductive land (sub divided into crop, pasture and forest), bioproductive sea, energy land (forested land and sea area required for the absorption of carbon emissions) and built land (buildings, roads etc.).

Figure 3: Summary of area types used for Ecological Footprint analysis[6]

For the purpose of this project all the Ecological Footprint results have been broken down into the aforementioned categorisation and the results can be seen below in Table 4.

[6] Source: Joe Ravetz, Manchester University

Table 4: Land type summary for Wales

	Total Ecological Footprint	Energy	Crop	Pasture	Built Land	Sea	Forest
	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap
Food and Drink a)	**1.29**	0.271	0.427	0.209	0.011	0.343	0.029
Energy	**0.92**	0.833	0.001	-	0.076	0.001	0.005
Travel b)	**0.78**	0.713	0.008	0.003	0.036	0.006	0.012
Housing	**0.17**	0.092	0.016	0.008	0.004	0.009	0.037
Consumables	**0.64**	0.355	0.123	0.058	0.017	0.033	0.053
Services	**0.24**	0.155	0.019	0.009	0.012	0.029	0.018
Holidays abroad	**0.10**	0.036	0.021	0.010	0.002	0.028	0.004
Capital Investment c)	**0.74**	0.560	0.034	0.016	0.013	0.009	0.112
Government d)	**0.41**	0.312	0.018	0.009	0.021	0.016	0.032
Other e)	**-0.03**	0.024	- 0.016	- 0.008	0.008	- 0.038	- 0.001
Total	**5.25**	**3.35**	**0.65**	**0.32**	**0.20**	**0.44**	**0.30**

a) includes catering services
b) includes transport services and air travel
c) Capital Investment or Gross Fixed Capital Formation (GFCF). The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.
d) Includes central and local government. The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.
e) includes non-profit institutions serving households, valuables, and changes in inventories and overseas tourists in the UK; the latter one leading to an overall negative Footprint.

2.3.2 THE MATERIAL FLOW ANALYSIS

A complementary approach to the Ecological Footprint method is a detailed investigation of resource flows, termed a Material Flow Analysis. The notion behind this is that the economy of a country relies heavily on materials and products that ‘flow’ into it and out of it. The analysis looks at the material flows of both production and consumption within Wales to provide a better understanding of the ‘weight’ of certain goods, services and activities.

Material flows of production, imports and exports in Wales

The analysis undertaken within this project should be seen as an approximation of actual material flows as most of the data were derived by using a model that is based on road transport of goods rather than real data from Welsh industries. Nevertheless, the analysis can give a meaningful insight to the abundance of material flows and their implications to sustainable consumption and production.

Table 5 demonstrates the material flows that are associated with industrial sectors in Wales. It shows the total tonnage of materials or products produced by each industry. Alongside this, the results also show the total tonnage of both imports and exports within each industrial sector. For example, the mining and quarrying industry moves the biggest amount of materials, producing 29 million tonnes of products, importing 1.3 and exporting almost 5 million tonnes. One important point to consider is that the origin and destination of the imports and exports at the Welsh level are not well known. For example, at present it is difficult to determine whether the exported tonnes of materials are being transported to other parts of the UK, to Europe or to other global destinations. The same principle applies to imports.

Table 5: Material flows linked to production in Wales in 2001 (all numbers in thousands of tonnes, kt)

123 IO code	Name of industry	PRODUCTION (P)	IMPORTS (I)	EXPORTS (E)	NET CONSUMPTION (= P+I-E)
1	Agriculture	1,360	2,200	869	2,690
2	Forestry	547	45	41	551
3	Fishing	36	11	31	15
4	Coal extraction	3,110	583	2,630	1,060
5	Oil and gas extraction	12,640	n.d.a.	n.d.a.	(12,640) [a)]
6	Metal ores extraction	n.d.a.	n.d.a.	n.d.a.	n.d.a.
7	Other mining and quarrying	29,130	1,340	4,980	25,490
8-20	Food processing (incl. tobacco)	2,440	990	202	3,220
21-27	Textile fibres	65	n.d.a.	39	(26)
28	Wearing apparel and fur products	8	16	5	19
29-30	Leather goods	3	25	2	26
31	Wood and wood products	584	625	139	1,070
32-33	Pulp, paper and paperboard	430	1,299	56	1,670
34	Printing and publishing	156	31	19	169
35	Coke ovens, refined petroleum & nuclear fuel	n.d.a.	n.d.a.	n.d.a.	n.d.a.
36	Industrial gases and dyes	32	24	19	37
37	Inorganic chemicals	161	118	57	222
38	Organic chemicals	321	176	269	227
39	Fertilisers	164	97	33	228
40	Plastics & synthetic resins etc	163	177	83	258
41	Pesticides	131	4	7	128
42	Paints, varnishes, printing ink etc	88	14	20	81
43	Pharmaceuticals	8	17	12	12
44	Soap and toilet preparations	72	51	59	65
45	Other chemical products	88	84	71	102
46	Mann.d.a.made fibres	18	33	8	43
47	Rubber products	64	41	29	76
48	Plastic products	315	170	105	381
49	Glass and glass products	38	92	6	124
50	Ceramic goods	15	99	5	110
51	Structural clay products	355	13	8	360
52	Cement, lime and plaster	869	46	79	836
53	Articles of concrete, stone etc	1,810	64	177	1,700
54	Iron and steel	4,080	247	355	3,970
55	Nonn.d.a.ferrous metals	326	305	165	466
56	Metal castings	65	n.d.a.	n.d.a.	(65)
57-61	Structural metal products	393	118	115	396
62-68	Mechanical power equipment	1,070	206	702	574
69	Office machinery & computers	11	24	12	23
70-72	Electric motors and generators etc	385	57	29	413
73-75	Electronic components	346	34	49	331
76	Medical and precision instruments	104	82	56	130
77	Motor vehicles	300	191	146	345
78-80	Shipbuilding and repair	341	13	3	351
81-84	Furniture	130	119	38	211
	Total material flows (rounded)	**62,800**	**9,880**	**11,700**	**(60,900)**

a) figures in brackets represent results that were calculated with insufficient data and should be seen as rough estimates only.
n.d.a. = no data available.

In total Wales produces 62.8 million tonnes of products in 2001. Of this, 11.7 million tonnes were exported out of Wales and a further 9.9 million tonnes were imported into the country. The major component of the material flows is made up from the mining and quarrying industry which are responsible for the production of 29 million tonnes of material (46 % of total material production). This sector is also responsible for 42% of total export, or 5 million tonnes, out of Wales. These figures are not too surprising however when one considers the weight of construction materials and the vast volumes that are required when creating new buildings and infrastructure.

Other large production volumes in Wales (in million tonnes, Mt) are oil and gas (13 Mt), iron and steel (4 Mt), agricultural products and processed food (3.8 Mt) and coal (3.1 Mt).

Material flows of consumption in Wales

The apparent net consumption in Wales (= production + imports – exports) is estimated to be 61 million tonnes of materials (see Table 6). A total of 61 million tonnes for Wales means that on average every Welsh resident consumes almost 21 tonnes of materials and products within one year. As with the Ecological Footprints it would be interesting to see what material flows are associated with certain consumption activities. During the project a methodology was developed to allocate material flows to consumption categories using input-output analysis and specific expenditure data for Wales. The results do not only show the materials and products that are directly consumed, but also account for the indirect material flows associated with upstream industrial production processes, including wastes and energy carriers used for extracting, transporting and producing materials. This demonstrates how material intensive the provision of products and services can be.

A breakdown of the total material flow for consumption (an estimated 61 million tonnes) by COICOP[7] classification is shown in Table 6. For lack of time and resources it was not possible to disaggregate the types of materials that are associated with each activity, so the numbers in Table 6 represent totals of a vast range of materials and products.

Table 6: Direct plus indirect material flows of final consumption activities in Wales

COICOP	Consumption activity	Total material flow associated with activity
	Household consumption	thousands of tonnes (kt)
	Food	
01.1	Food	6,950
01.2	Non-alcoholic beverages	560
02.1	Alcoholic beverages	959
11.1	Catering services	3,950
	Energy	
	Domestic Energy Consumption	1,840
04.5	Electricity, gas and other fuels	4,010
	Transport	
	Private transport (car fuel)	2,350
07.1	Purchase of vehicles	782
07.2	Operation of personal transport equipment	2,390
07.3	Transport services	633
	Infrastructure	
04.1	Actual rentals for housing	369
04.2	Imputed rentals for housing	837
04.3	Maintenance and repair of the dwelling	971
	Consumables	

[7] Classification Of Individual Consumption by Purpose

COICOP	Consumption activity	Total material flow associated with activity
02.2	Tobacco	199
09.5	Newspapers, books and stationery	266
12.1	Personal care	300
	Durables	
03.1	Clothing	251
03.2	Footwear	142
05.1	Furniture, furnishings, carpets and other floor coverings	232
05.2	Household textiles	152
05.3	Household appliances	1,050
05.4	Glassware, tableware and household utensils	167
05.5	Tools and equipment for house and garden	186
05.6	Goods and services for routine household maintenance	116
06.1	Medical products, appliances and equipment	109
08.2	Telephone and telefax equipment	3
09.1	Audio-visual, photo and inf. processing equipment	937
09.2	Other major durables for recreation and culture	128
09.3	Other recreational items & equipment	1,550
12.3	Personal effects n.e.c.	818
	Water	
04.4	Water supply and miscellaneous dwelling services	209
	Services	
06.2	Out-patient services	27
06.3	Hospital services	49
08.1	Postal Services	13
08.3	Telephone and telefax services	243
09.4	Recreational and cultural services	550
09.6	Package holidays	-
10.	Education	128
11.2	Accommodation services	508
12.4	Social protection	186
12.5	Insurance	512
12.6	Financial services n.e.c.	234
12.7	Other services n.e.c.	189
	UK resident holidays abroad	1,309
	Total Household Consumption	***36,500***
	Other consumption	
	Non-profit institutions serving households	495
	Central government	2,640
	Local government	1,800
	Capital investment	15,750
	Valuables	- 4
	Changes in inventories	3,760
	Overseas tourists in the UK	-855
	Total Other Consumption in Wales	***24,400***
	Total (estimated) consumption of materials	**60,900**

From the above table it can be seen that the total material flows of household consumption add up to approximately 37 million tonnes. The largest material flow is that associated with the provision of food, amounting to over 12.4 million tonnes of materials over a one year period. This equates to 4.3

tonnes per person. Of course, these are not food products alone. One person eats about 600 kilogrammes of food per year. The remaining 3.7 tonnes are other materials that are indirectly needed to provide the food, like packaging, construction materials for warehouses and supermarkets, fuel for transport and so on. These indirect flows of materials often – like in this example – exceed the direct flows.

Other material intensive categories are domestic energy and electricity consumption with 5.9 million tonnes (2 t/cap) and private cars including the fuel with 4.7 million tonnes (1.6 t/cap). When looking at the non-household consumption categories capital investment (gross fixed capital formation) makes up the most material intensive component with almost 16 million tonnes. This is because a large part of capital is invested in construction and machinery, both of which are very material intensive.

2.3.3 CARBON DIOXIDE EMISSIONS

Carbon dioxide is a gas naturally occurring in our atmosphere. Human activities, such as driving a car or using electricity, are responsible for releasing extra carbon dioxide and hence increasing the concentration beyond its naturally occurring level. Carbon dioxide is widely known to be one of the major greenhouse gases. By increasing the concentrations present in our atmosphere we are subjecting the planet to the consequences of future global warming.

In order to abate the proliferation of greenhouse gases (GHGs) and thus stop/slow down global warming, it is necessary to investigate deeply the major sources of GHGs (Bastianoni et al., 2004)[8]. It is important not only to identify fuel consumption as the main source of these emissions, but also to localise where these gases are emitted, why they are emitted and which economic sectors are involved in the emissions. However, without attributing responsibility for GHG emissions, their reduction and abatement will remain an arduous task. Therefore, more attention should be drawn to the need for a fair accounting method to create a GHG inventory that also assigns responsibility for emissions.

The Intergovernmental Panel on Climate Change (IPCC, 1996)[9] has defined a complete method to standardise the GHG inventory at a local level. In the guidelines set by the IPCC, GHG emissions data are mostly based on estimates, as emissions from very few sources can be measured directly and continuously. The estimate of emissions from each source is based on the assumption of a relationship between a certain activity and the emissions it generates. Furthermore, the emission factors are determined while taking national scenarios into account wherever possible. Unfortunately, such emission inventories may have uncertainties of up to 20 per cent due to process variability in space and time and appropriate estimation models are not always available.

As an alternative to the principle of territorial responsibility, other approaches have been proposed in order to suggest more efficacious and fair policies, mainly distinguishing between *consumer* and *producer responsibility*. For example, Munksgaard and Pedersen (2001)[10] link the concept of responsibility to the production and consumption accounting principles. In the following, the two approaches shall be briefly explained.

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[8] Most of the discussion in this section has been adopted from Bastianoni, S., Pulselli, F.M., Tiezzi, E. (2004) The problem of assigning responsibility for greenhouse gas emissions. Ecological Economics 49, 253– 257.

[9] IPCC, 1996. Guidelines for national greenhouse gas inventories, vol. 1 –3. Intergovernmental Panel on Climate Change, London.

[10] Munksgaard, J., Pedersen, K.A., 2001. CO_2 accounts for open economies: producer or consumer responsibility? Energy Policy 29, 327– 334.

The first approach – proposed by IPCC – suggests merely applying a *geographical approach*: the accounting should only consider the carbon dioxide emissions directly involved in each sector of the analysed nation within the country boundaries. In this case, the contribution to global GHG emission is evaluated for each emission source at the local level without including, for example, fuel combustion indirectly related to the system, such as transportation. However, if we consider a country that only imports transformed goods, without transforming them within the country's boundaries, we might observe a paradoxical situation of a high standard of living coupled with a very low level of GHG emissions. On the contrary, a country that produces goods for another country would have to "pay" for the carbon dioxide associated with something they will never benefit from.

These considerations have driven to an opposite accounting perspective based on the *consumer responsibility* (see, e.g. Munksgaard and Pedersen, 2001; Ferng, 2003)[11] that can be regarded in the same stream as the Ecological Footprint approach. This sees every economic activity, be it performed by a single individual or a whole country, as having an impact on the Earth due to the consumption of nature's products and services, so the ecological impact corresponds to the amount of natural wealth destroyed, consumed, altered or occupied. The Ecological Footprint is based on the actual consumption of goods by a country's inhabitants, so if something is produced in country X and used in country Y, the land requirement is registered totally within country Y. Thus, if the consumer of a final product is responsible for the entire ecological impact of the process that has generated that product, the consumer should be charged for the total emissions related to the process. As a result, the GHG inventory, carried out on the basis of the Ecological Footprint approach assign a lower level of GHG emissions to developing (or exporting) countries and a higher level to developed ones (or importing). This type of accounting can be seen as "fairer" because it makes final users pay the GHG "bill", but it would lower the incentive for developing (exporting) countries to create cleaner and more efficient production processes. In any case, this solution would avoid the problem of having to transfer production from countries with limited emissions towards developing countries (with almost no limit on emissions). Assuming a consumer responsibility viewpoint, producers are not directly motivated to reduce emissions, while consumers, instead, should in theory assume responsibility for choosing the best strategies and policy by showing a preference for producers who are attentive to GHG reductions. However, without adequate incentives or policies, consumers are not likely to be sensitive with respect to their environmental responsibilities, having in fact no consumption limits.

It can be concluded that both approaches – producer and consumer responsibility – have their justification and assessments should be made by taking both into account.

During this project, CO_2 emissions were calculated according to the consumer responsibility principle by converting fossil fuel energy Footprints into the corresponding CO_2 emissions (for the methodology see the appendix to this report). Table 7 and Figure 4 show a comparison of the carbon dioxide emissions in Wales and the UK between the two methods described above.

Table 7: Comparison of actual (territorial) CO_2 emissions and CO_2 emissions for which consumers are responsible.

CO_2 emissions per capita	UK (2000) [t/cap/yr]	Wales (2001) [t/cap/yr]

[11] Ferng, J.J., 2003. Allocating the responsibility of CO_2 over-emissions from the perspectives of benefit principle and ecological deficit. Ecological Economics 46, 121– 141.

Producer responsibility (territorial emissions)	**10.3** ± 0.2 a)	**14.5** ± 0.3 a)
Consumer responsibility	**11.5** ± 0.4 b)	**11.3** ± 0.4 b)

a) range of uncertainty Γ 2% (see http://www.naei.org.uk/emissions/emissions_2002.php?action=notes1)
b) range of uncertainty deduced with method described below
Data source for territorial emissions in the UK (= 606 Mt of CO_2 in 2000): ONS, 2004. Environmental Accounts: Emissions; Greenhouse gases, 93 economic sectors, 1990-2002, revised 2004. Office for National Statistics, London. Table download at: http://www.statistics.gov.uk/statbase/Publication.ASP?to=1&su=30&B3.x=23&B3.y=14
Data source for territorial emissions in Wales (= 42.1 Mt of CO2 in 2000): Key Statistics for Wales; http://www.wales.gov.uk/keypubstatisticsforwales/content/publication/environment/2004/sb8-2004/sb8-2004.pdf
Data source for population in the UK and Wales: ONS, 2003e. Statbase Datasets. Revised UK population 2000. Office for National Statistics, London. Table download at: www.statistics.gov.uk/popest
Data source for UK energy Footprint from fossil fuels (= 3.02 gha/cap): Moran, 2004[12]

At present, no commonly accepted method for calculating CO_2 emission according to the consumer responsibility principle has been produced yet. Therefore, two approaches have been employed: the National Footprint Accounts use the IPCC sectoral approach to account for CO_2 emissions (emissions from actually combusted fuels). They then add a "World Bunker Fuel Burden" that is supposed to represent the actual use of bunker fuels. CO_2 emissions embodied in imports and exports are estimated by using embodied energy figures for goods. The uncertainty with these embodied emissions is relatively high. The actual numbers for the UK in the year 2000 (in Mt/yr) are:

Territorial Emissions: 550 (note: the Environmental Accounts bridging table suggests that 558 were reported to IPCC)
World Bunker Fuel Burden: 25
Embodied in Imports of Goods: 308
Embodied in Exports of Goods: -181

Therefore, apparent consumption: 702
which is 606 plus 16% (606 Mt from Environmental Accounts).

In contrast, the input-output calculations developed in this project suggest that the NFA method underestimates the emissions embodied in exports (e.g. the NFA method does not take into account the export of services). While the emissions associated with exports may actually occur on UK territory, they should be subtracted from the total from a responsibility point of view. After subtraction of export, the resulting numbers (in Mt/yr) are:

Households: 339
Government: 58
Capital investment: 110
Other final demand: 4
Domestic fuel consumption: 83
Private transport: 59
Exports: 230

Therefore, total final demand without exports: 653
which is 606 plus 8%.

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[12] Moran, D., 2004. Updated version of the National Footprint Account spreadsheet for the United Kingdom in the year 2000. Personal communication, November 2004. Global Footprint Network, Oakland, CA, USA.

For this reason, the average of 12% for the 'overseas impact' (i.e. the CO_2 emissions embodied in imported goods) and a range of uncertainty form 8% to 16% were adopted.

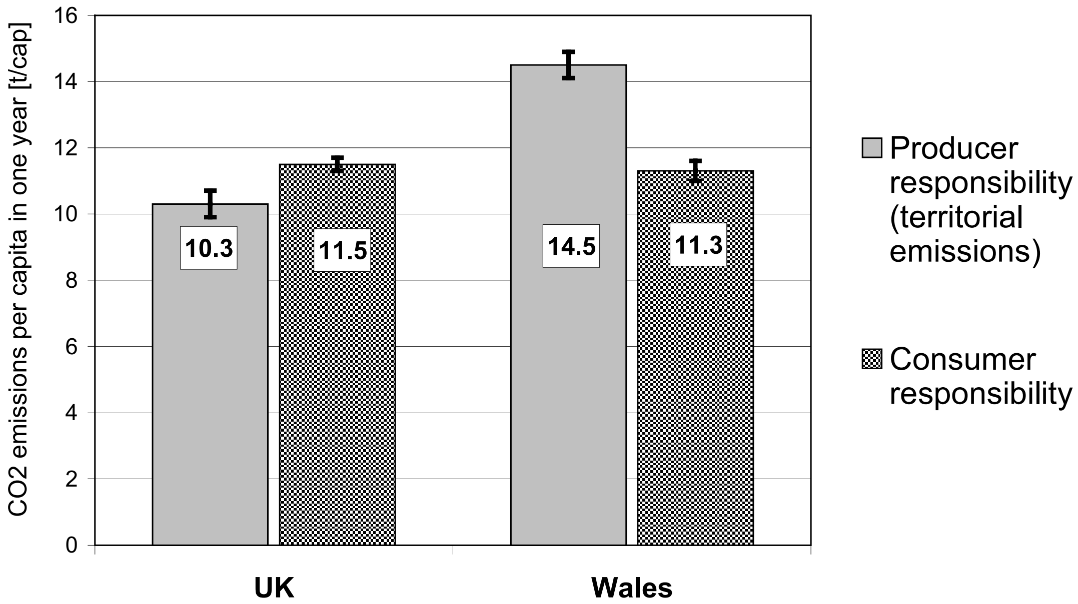

Figure 4: Graphic comparison of actual (territorial) CO_2 emissions and CO_2 emissions for which consumers are responsible.

The results in Table 7 and Figure 4 show some interesting information. Using the '**consumer responsibility**' approach (as is used by the Ecological Footprint and this project) each person in Wales is responsible for 11.3 tonnes of CO_2 through his or her consumption of materials and fossil fuels. The '**producer responsibility**' approach (emissions that are actually released on the territoy of Wales) shows a very different picture. Here we see that 14.5 tonnes of carbon dioxide are being released per person within one year. Therefore, in Wales the consumption of carbon dioxide is lower than what is produced within its boundaries. This is a rather surprising result as in the UK it's the other way round: each UK resident is responsible for 10.3 tonnes of carbon dioxide under territorial emissions and 11.5 for consumption. This means that the UK as a whole 'imports' CO_2 emissions that have occurred during the production of products that are then imported into the UK. This "overseas impact" is an estimated 12% of the territorial emissions.

An explanation why the per capita emissions in Wales are so high comes from heavy industry: refineries, iron and steel, electricity production etc. The fact that consumer emissions are in Wales are significantly lower demonstrates that in terms of carbon dioxide emissions Wales is carrying the environmental burden for consumption that occurs outside its territorial boundaries.

The breakdown of carbon dioxide emissions for the UK and Wales is shown in Table 8 below. This breakdown has used the consumer responsibility principle.

Table 8: Breakdown of 'consumer responsibility' carbon dioxide emissions in the UK and Wales

CO_2 emissions per capita	**UK (2000)** [t/cap/yr]	**Wales (2001)** [t/cap/yr]
Food and Drink a)	0.94	0.91

CO_2 emissions per capita	UK (2000) [t/cap/yr]	Wales (2001) [t/cap/yr]
Energy	2.73	2.79
Travel b)	2.21	2.39
Housing	0.33	0.31
Consumables	1.49	1.28
Services	0.67	0.52
Holidays abroad	0.14	0.12
Capital Investment c)	1.87	1.87
Government d)	1.04	1.04
Other e)	0.08	0.08
Total	**11.5**	**11.3**

a) includes catering services

b) includes transport services and air travel

c) Capital Investment or Gross Fixed Capital Formation (GFCF). The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.

d) Includes central and local government. The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.

e) includes non-profit institutions serving households, valuables, changes in inventories and overseas tourists in the UK; the latter one leading to an overall negative Footprint.

The biggest contribution to climate relevant emissions comes from energy consumption. Whenever we use energy, whether it is through the direct combustion of fuels or indirect as with electricity, we are releasing carbon dioxide into the atmosphere. Emissions from energy consumption in Wales total 2.8 tonnes per resident. The second largest contributor, 2.4 tonnes of carbon dioxide per resident in 2001, is from private transport. Here, Welsh residents emit more than the average UK resident (2.2 t/cap). This is compensated by the impact associated with consumables where Welsh emissions are lower – 1.3 and 1.5 t/cap for Wales and the UK, respectively.

For a more detailed breakdown of the results please refer to the appendix to this chapter.

2.3.4 SUMMARY OF RESULTS

Figure 5 shows a comparison of the total results by activity categories. Table 11 in the appendix to this chapter contains the data for this graph. As can be seen, different indicators bring out the implications of different activities. The Ecological Footprint demonstrates that food and drink consumption requires the most land area of any activity, whereas the energy sector is responsible for the most carbon dioxide emissions. Obviously, the biggest impact in terms of material flows comes from the construction sector; this is represented in terms of 'capital investment'.

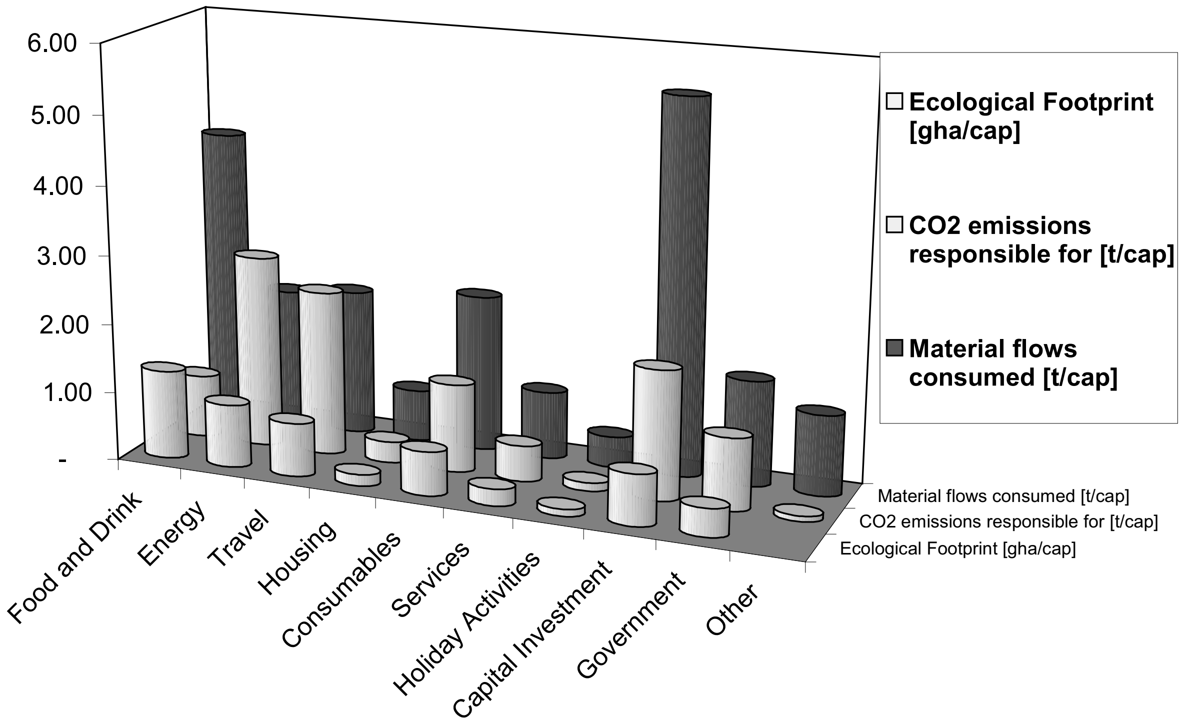

Figure 5: Comparison of indicators by component

When looking at the results it can be seen that both the Ecological Footprint and carbon dioxide emissions generally follow the same pattern. This is due to the fact that one major component of the Ecological Footprint is looking at the land needed to absorb carbon dioxide. The only outlier is for the 'food and drink' consumption category. Here the Ecological Footprint indicates a much higher ecological pressure than is shown by the carbon dioxide indicator. The reason for this is that the consumption of food and drink require much direct land consumption, highly increasing the Ecological Footprint value.

2.3.5 DEVELOPMENT OF GLOBAL RESPONSIBILITY INDICATORS

A number of key indicators for Wales, concerned with global responsibility and sustainable consumption can be drawn from the results. The indicator selected below do in some capacity "fit in" with proposed indicators put forward by DEFRA to support the "Sustainable Consumption and Production Framework". There is the danger that the current indicators proposed by DEFRA show a decoupling that takes place only within the national boundaries. Thus someone might be deluded into thinking that the trend is towards sustainability whereas in fact unsustainable production processes and emissions have merely been "exported". To overcome this a number of suggested indicators have been added.

The indicators below will ensure that Wales has a clear understanding of how they are going to achieve and go beyond Kyoto targets, ensure that they are constantly reducing the global environmental burden of Wales and finally that they are using a minimal amount of resources.

As well as two headline indicators, detailed sets of indicators have been provided for three components. These are consumables (which includes waste), energy and transport. For each of these both overall indicators of environmental pressure have been included as well as indicators of "Eco-

Efficiency" (otherwise known as "Y/e" measures). The Y/e measure is based on the idea that resource productivity is defined by Y/*m* when Y = output (measured in monetary or physical terms) and *m* is a measure of resource input (typically measured in physical terms). However, in order to include some concept of environmental impacts, the equation is rewritten as Y/e where e = emissions. Y/e then becomes an expression of output per unit of emissions. This will give an insight into whether the Ecological Footprint is providing information that contradicts other headline indicators or supports the patterns and trends of those indicators.

Headline Indicator 1 – Ecological Footprint of Wales	**5.25 gha/cap**
Headline Indicator 2 – Greenhouse Gas Emissions of Consumption	**11.3 t/cap**

Household Consumption Patterns

As waste is seen as such an important issue a set of indicators concentrating on household consumption have been formulated, because ultimately everything that is purchased by households will end up as waste. To ensure a shift from just addressing "end-of-pipe" solutions the indicator set does mainly focus on the "front end" of the economic cycle. Indicator 1, 2 and 4 provide an overall of whether the total impact of household consumption is getting better or worse with a particular emphasis on the Ecological Footprint, materials and CO_2 emissions. Indicator 3 concentrates on ensuring that waste minimisation is undertaken at the end of a products lifetime. Finally, indicator 5 acts as a Y/e measure. This provides an insight into where improvements are being made (i.e. increase in eco-efficiency or change in consumption patterns)

1. EF of household consumables	0.64 gha/cap
2. Tonnes of material entering the household	7.3 t/cap
3. Household waste production per capita	0.46 t/cap
4. CO_2 responsibility of consumables per capita	1.3 t/cap
5. Eco-Efficiency Measure – EF per tonne of HH products	0.28 gha/tonne

Energy Use in Wales

Energy use by households in Wales has a significant impact and represents a high proportion of total CO_2 emissions. It is also very topical in light of the Kyoto agreement and the recent public debate on what form of energy generation will be required to provide low CO_2 emissions. Indicator 1 provides the total Ecological Footprint of household energy use, while indicator 2 provides a similar profile for CO_2 emissions. Indicator 3 acts as the "Eco-Efficiency" indicator and will be responsive to changes in the "Energy Mix" in Wales.

1. Household Energy Footprint per capita	0.92 gha/cap
2. Household CO_2 emissions per capita	2.8 t/cap
3. Eco-Efficiency Measure – CO_2 per unit of energy	0.25 kg CO_2/kWh

Transport in Wales

Transport is the fastest growing sector in terms of CO_2 emissions. Transport forms a significant threat to achieving CO_2 reduction targets. The indicators selected measure both the total impact of the transport sector (indicators 1 and 2), as well as the efficiency of road travel. Finally, an indicator has also been included on the issue of air travel because this is a major concern in relationship to its growth in Wales.

EF of road travel per capita	0.78 gha/cap
CO_2 emission of road travel per capita	2.4 t CO_2/cap
CO_2 emissions of air travel per capita	0.60 t/cap
Eco-Efficiency Measure – CO_2 per passenger-km	0.23 kg CO_2/pkm

2.4 Appendix to Chapter 2

Table 9: UK and Wales total Ecological Footprints disaggregated by COICOP final demand categories(all number in global hectares per capita, gha/cap)

COICOP	Direct Household Consumption	UK (2000) gha/cap	Wales (2001) gha/cap
	Food		
01.1	Food	0.770	0.748
01.2	Non-alcoholic beverages	0.050	0.048
02.1	Alcoholic beverages	0.078	0.083
11.1	Catering services	0.439	0.411
	Energy		
	Domestic Energy Consumption	0.545	0.512
04.5	Electricity, gas and other fuels	0.357	0.405
	Transport		
	Private transport (car fuel)	0.287	0.276
07.1	Purchase of vehicles	0.116	0.109
07.2	Operation of personal transport equipment	0.103	0.130
07.3	Transport services	0.092	0.066
	Aviation	0.124	0.198
	Infrastructure		
04.1	Actual rentals for housing	0.033	0.034
04.2	Imputed rentals for housing	0.075	0.076
04.3	Maintenance and repair of the dwelling	0.067	0.057
	Consumables		
02.2	Tobacco	0.024	0.024
09.5	Newspapers, books and stationery	0.029	0.026
12.1	Personal care	0.028	0.023
	Durables		
03.1	Clothing	0.029	0.022
03.2	Footwear	0.012	0.010
05.1	Furniture, furnishings, carpets and other floor coverings	0.057	0.049
05.2	Household textiles	0.013	0.013
05.3	Household appliances	0.115	0.095
05.4	Glassware, tableware and household utensils	0.011	0.007
05.5	Tools and equipment for house and garden	0.017	0.019
05.6	Goods and services for routine household maintenance	0.009	0.008
06.1	Medical products, appliances and equipment	0.010	0.008
08.2	Telephone and telefax equipment	0.000	0.000
09.1	Audio-visual, photo and inf. processing equipment	0.069	0.072
09.2	Other major durables for recreation and culture	0.020	0.012
09.3	Other recreational items & equipment	0.187	0.200

COICOP	Direct Household Consumption	UK (2000) gha/cap	Wales (2001) gha/cap
12.3	Personal effects n.e.c.	0.123	0.080
	Credits for recycling	- 0.108	- 0.027
	Water		
04.4	Water supply and miscellaneous dwelling services	0.018	0.021
	Services		
06.2	Out-patient services	0.006	0.002
06.3	Hospital services	0.004	0.004
08.1	Postal Services	0.002	0.001
08.3	Telephone and telefax services	0.023	0.018
09.4	Recreational and cultural services	0.042	0.042
09.6	Package holidays	-	-
10.	Education	0.026	0.013
11.2	Accommodation services	0.071	0.053
12.4	Social protection	0.025	0.017
12.5	Insurance	0.046	0.037
12.6	Financial services n.e.c.	0.033	0.018
12.7	Other services n.e.c.	0.022	0.017
	UK resident holidays abroad	0.122	0.101
	Other consumption (other final demand)		
	Infrastructure (Shared)		
	Gross fixed capital formation	0.744	0.744
	Non-profit institutions serving households	0.052	0.052
	Central government	0.241	0.241
	Local government	0.167	0.167
	Valuables	- 0.001	- 0.001
	Changes in inventories	0.010	0.010
	Overseas tourists in the UK	- 0.093	- 0.093
	TOTAL EF including aviation	**5.35**	**5.25**

Table 10: Wales total Ecological Footprints, disaggregated land types and CO_2 emissions according to the consumer responsibility principle (year 2001; all number in global hectares per capita, except CO_2 emissions which are in tonnes per capita)

COICOP	Consumption Category	Total Ecol. Footprint	Energy	Crop	Pasture	Built Land	Sea	Forest	CO_2 emissions
	Household consumption	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	t/cap
	Food								
01.1	Food	**0.748**	0.118	0.316	0.155	0.002	0.147	0.010	0.40
01.2	Non-alcoholic beverages	**0.048**	0.012	0.013	0.006	0.000	0.016	0.001	0.04
02.1	Alcoholic beverages	**0.083**	0.020	0.022	0.011	0.000	0.028	0.002	0.07
11.1	Catering services	**0.411**	0.120	0.077	0.037	0.008	0.152	0.016	0.41
	Energy								
	Domestic Energy Consumption	**0.512**	0.434	-	-	0.075	-	0.002	1.47
04.5	Electricity, gas and other fuels	**0.405**	0.399	0.001	0.000	0.001	0.001	0.002	1.35
	Transport								
	Private transport (car fuel)	**0.276**	0.247	-	-	0.029	-	-	0.83
07.1	Purchase of vehicles	**0.109**	0.099	0.002	0.001	0.001	0.001	0.005	0.33
07.2	Operation of personal transport equipment	**0.130**	0.113	0.005	0.002	0.004	0.002	0.005	0.38
07.3	Transport services	**0.066**	0.057	0.002	0.001	0.002	0.003	0.002	0.19
	Aviation	**0.198**	0.198	-	-	-	-	-	0.60
	Infrastructure								
04.1	Actual rentals for housing	**0.034**	0.018	0.004	0.002	0.001	0.002	0.006	0.06
04.2	Imputed rentals for housing	**0.076**	0.041	0.010	0.005	0.002	0.005	0.013	0.14
04.3	Maintenance and repair of the dwelling	**0.057**	0.033	0.002	0.001	0.001	0.001	0.019	0.11
	Consumables								
02.2	Tobacco	**0.024**	0.005	0.012	0.005	0.000	0.000	0.001	0.02
09.5	Newspapers, books and stationery	**0.026**	0.019	0.001	0.0001	0.000	0.001	0.005	0.06
12.1	Personal care	**0.023**	0.019	0.001	0.0002	0.001	0.0002	0.002	0.07
	Durables								
03.1	Clothing	**0.022**	0.018	0.001	0.000	0.001	0.000	0.001	0.06
03.2	Footwear	**0.010**	0.006	0.001	0.001	0.001	0.001	0.001	0.02
05.1	Furniture, furnishings, carpets and other floor coverings	**0.049**	0.040	0.001	0.0001	0.0003	0.0002	0.008	0.14
05.2	Household textiles	**0.013**	0.010	0.001	0.0002	0.0003	0.0003	0.001	0.04
05.3	Household appliances	**0.095**	0.061	0.010	0.005	0.005	0.009	0.005	0.21
05.4	Glassware, tableware and household utensils	**0.007**	0.006	0.00009	0.00004	0.0002	0.00009	0.0004	0.02
05.5	Tools and equipment for house and garden	**0.019**	0.013	0.0004	0.0002	0.0002	0.0004	0.004	0.04
05.6	Goods and services for routine household maintenance	**0.008**	0.006	0.0003	0.0001	0.0002	0.0003	0.0005	0.02
06.1	Medical products, appliances and equipment	**0.008**	0.006	0.001	0.0002	0.0002	0.0003	0.0005	0.02
08.2	Telephone and telefax equipment	**0.0002**	0.0002	0.000008	0.000004	0.000005	0.000007	0.00001	0.00
09.1	Audio-visual, photo and inf. processing equipment	**0.072**	0.050	0.005	0.003	0.003	0.005	0.006	0.17

COICOP	Consumption Category	Total Ecol. Footprint	Energy	Crop	Pasture	Built Land	Sea	Forest	CO_2 emissions
	Household consumption	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	gha/cap	t/cap
09.2	Other major durables for recreation and culture	**0.012**	0.007	0.002	0.001	0.0002	0.0003	0.001	0.02
09.3	Other recreational items & equipment	**0.200**	0.066	0.078	0.038	0.001	0.007	0.010	0.22
12.3	Personal effects n.e.c.	**0.080**	0.048	0.008	0.004	0.004	0.008	0.008	0.16
	Credits for recycling	**-0.027**	-0.027	-	-	-	-	-	-
	Water								
04.4	Water supply and miscellaneous dwelling services	**0.021**	0.019	0.0002	0.0001	0.0012	0.0002	0.0007	0.06
	Services								
06.2	Out-patient services	**0.002**	0.002	0.0001	0.0001	0.0001	0.0001	0.0002	0.01
06.3	Hospital services	**0.004**	0.003	0.0003	0.0001	0.0002	0.0002	0.0003	0.01
08.1	Postal Services	**0.001**	0.001	0.00004	0.00002	0.00003	0.00004	0.00006	0.00004
08.3	Telephone and telefax services	**0.018**	0.015	0.001	0.0001	0.001	0.001	0.001	0.05
09.4	Recreational and cultural services	**0.042**	0.026	0.003	0.001	0.003	0.003	0.005	0.09
09.6	Package holidays	**-**							
10.	Education	**0.013**	0.009	0.001	0.0004	0.001	0.0005	0.001	0.03
11.2	Accommodation services	**0.053**	0.015	0.010	0.005	0.001	0.020	0.002	0.05
12.4	Social protection	**0.017**	0.011	0.001	0.001	0.001	0.002	0.001	0.04
12.5	Insurance	**0.037**	0.028	0.001	0.001	0.002	0.001	0.004	0.10
12.6	Financial services n.e.c.	**0.018**	0.014	0.001	0.0003	0.001	0.001	0.001	0.05
12.7	Other services n.e.c.	**0.017**	0.012	0.001	0.0002	0.002	0.001	0.002	0.04
	UK resident holidays abroad	**0.101**	0.036	0.021	0.010	0.002	0.028	0.004	0.12
	Total household consumption	***4.14***	*2.450*	*0.616*	*0.296*	*0.157*	*0.446*	*0.159*	*8.21*
	Other Consumption								
	Infrastructure (Shared)								
	Gross fixed capital formation	**0.744**	0.560	0.034	0.016	0.013	0.009	0.112	1.89
	Non-profit institutions serving households	**0.052**	0.034	0.003	0.002	0.007	0.002	0.004	0.12
	Central government	**0.241**	0.188	0.010	0.005	0.009	0.010	0.019	0.64
	Local government	**0.167**	0.124	0.008	0.004	0.011	0.006	0.013	0.42
	Valuables	**-0.001**	-0.001	0.0001	0.00005	0.00005	0.0001	0.00008	- 0.003
	Changes in inventories	**0.010**	0.023	-0.004	-0.002	0.002	-0.008	-0.001	0.08
	Overseas tourists in the UK	**-0.093**	-0.032	-0.016	-0.008	-0.002	-0.032	-0.004	- 0.11
	Total Other Consumption	***1.21***	*0.896*	*0.035*	*0.017*	*0.04*	*-0.013*	*0.143*	*3.13*
	TOTAL Ecological Footprint	**5.25**	**3.34**	**0.65**	**0.32**	**0.20**	**0.44**	**0.30**	**11.3**

Table 11: Comparison of indicators, Wales 2001

	Ecological Footprint Wales [gha/cap]	Material flows consumed [t/cap/year]	CO_2 emissions responsible for [t/cap/year]
Food and Drink a)	1.29	4.3	0.91
Energy	0.92	2.0	2.79
Travel b)	0.78	2.1	2.39
Housing	0.17	0.7	0.31
Consumables	0.64	2.3	1.28
Services	0.24	1.0	0.52
Holidays abroad	0.10	0.5	0.12
Capital Investment c)	0.74	5.4	1.87
Government d)	0.41	1.5	1.04
Other e)	-0.03	1.2	0.08
Total	**5.25**	**21.0**	**11.3**

a) includes catering services

b) includes transport services and air travel

c) Capital Investment or Gross Fixed Capital Formation (GFCF). The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.

d) Includes central and local government. The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.

e) Includes non-profit institutions serving households, valuables, changes in inventories and overseas tourists in the UK; the latter one leading to an overall negative Footprint.

3. Food

3.1 Results

3.1.1 INTRODUCTION

The food system has changed significantly during the last fifty years based on the assumption that the consumer wants cheaper food, greater variety and non-seasonal food all year round. Farms have become highly mechanised, larger and more specialised and the distance between food producer and consumer has increased as food supply chains have become more complicated and transport-intensive. In the last few years production and consumption of organic food has grown rapidly but in Wales has only reached a level of 3.2 per cent for production and 1.1 per cent for consumption of all food.

Food retailing has become concentrated within a small number of multiple retailers, with many of their stores located away from the traditional high street, now accounting for over three-quarters of UK food sales. Take-away food and ready to eat meals have been introduced and are extremely successful. These changes have influenced the resource consumption and environmental impacts of food supply. Figure 6 provides a simplified version of the food supply chain; in practice there will be considerably more processes and transport stages.

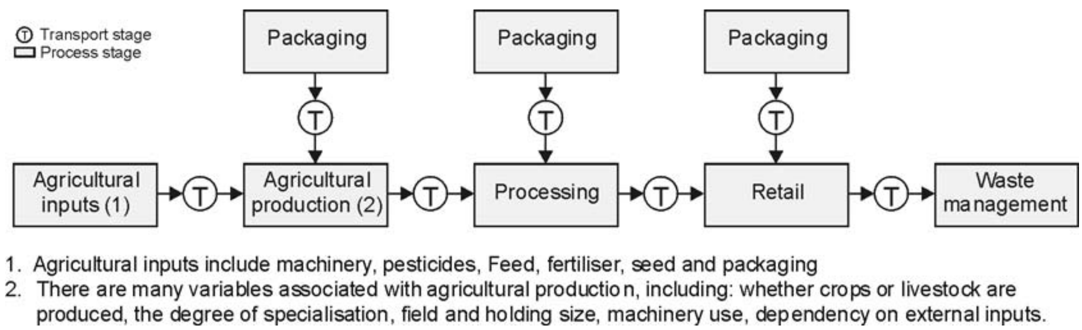

Figure 6: A basic representation of a food supply chain

The total Ecological Footprint for food consumption includes both the pasture or crop land area required to produce the food as well as the notional 'energy land' area required (to sequester the carbon from the CO_2 emissions associated with the embodied energy of food production and processing). Our analysis of the food system in Wales includes actual material flows, embodied energies, packaging and transportation of food products. As with all the components the Ecological Footprint calculations rely on the use of Input-Output Tables, as explained in The appendix, allowing all the inter-industry interactions to be included.

3.1.2 MATERIAL FLOWS OF FOOD PRODUCTION AND CONSUMPTION IN WALES

In total 3.2 million tonnes of food and drink were produced in Wales in 2001. This could theoretically cover the entire consumption of all Welsh residents, which totals 3.1 million tonnes. However, local supply and demand varies largely by food type, as the detailed breakdown of food products consumed and produced in Wales shows (see Table 12). Many food products are imported from either the rest of the UK or from overseas. In turn much of the food produced in Wales is not consumed within the country but is being exported.

More key findings include:

- The main food production sectors in Wales are dairy products, meat, vegetables and drinks, which account for 30%, 12%, 12% and 24% of total mass produced, respectively.
- Dairy products and meat are the two main food product groups where Wales produces roughly twice as much as its residents consume.
- 1.7 million tonnes of food or 578 kg per capita are consumed in households, while 180,000 tonnes (61 kg/cap) where eaten out.
- Another 1.2 million tonnes of food are consumed elsewhere, e.g. during lunch breaks or in hospitals.
- Altogether, total food and drink consumption amounts to 3.1 million tonnes which means that more than 1 tonne of food products are consumed by an average Welsh person during the course of one year.
- In terms of their mass consumed the main food product groups are dairy products (13%), vegetables (18%), bread and cereal products (16%) and drinks (20%).

The production and consumption of organic food is described in detail in section 4.3 below.

Table 12: Total quantities of food products produced and consumed in Wales in 2001 (all numbers in thousands of tonnes)

	Food in Wales	Total UK Production	Wales Production	Household Consumption Wales	Eating Out Consumption Wales	Other Consumption Wales	Total Consumption Wales	Production vs. Consumption
No.	Food category	kt	kt	kt	kt	kt	kt	%
1	MILKS AND CREAMS	7,728	888	334	6.12	50.6	391	227%
2	Liquid whole milk	2,349	270	114	-	10.0	124	217%
3	Skimmed milks	3,844	442	179	1.97	14.1	194	227%
4	Other milks and dairy desserts	634	73.0	19.2	3.07	3.43	25.7	284%
5	Yoghurt and fromage frais	412	47.4	20.4	1.08	4.76	26.3	180%
6	Cream	486	55.9	1.84	-	18.3	20.1	278%
7	CHEESE	525	60.5	17.4	0.37	17.9	35.7	169%
8	Cheese, natural	437	50.4	15.5	-	14.8	30.4	166%
9	Cheese, processed	87.5	10.1	1.84	0.37	3.1	5.31	190%
10	MEAT	5,277	396	144	14.91	60.5	220	180%
11	Beef and Veal	517	63.2	16.1	-	7.22	23.4	271%
12	Mutton and Lamb	222	59.1	12.1	-	2.95	15.1	392%
13	Pork	461	4.86	8.61	-	3.79	12.4	39%
14	Bacon and Ham, uncooked	199	2.09	10.6	-	4.18	14.8	14%
15	Bacon and Ham, cooked including canned	473	4.98	8.15	-	2.44	10.6	47%
16	Poultry, uncooked	1,321	103	30.3	-	11.8	42.1	246%
17	Poultry, cooked not canned	661	51.8	7.84	3.07	3.40	14.3	362%
18	All other meat and meat products	1,419	106	50.9	11.8	24.7	87.4	122%
19	FISH	611	8.55	20.3	3.38	15.6	39.3	22%
20	Fresh fish	221	3.10	3.84	1.69	0.18	5.7	54%
21	Processed and shell	12.7	0.18	1.84	-	-	1.8	10%
22	Prepared, including fish products	284	3.98	7.38	-	13.8	21.2	19%
23	Frozen, including fish products	92.2	1.29	7.22	1.69	1.70	10.6	12%
24	EGGS	582.6	21.6	18.1	0.56	1.64	20.3	106%
25	FATS AND OILS	1,841	40.4	31.4	0.46	83.9	115	35%
26	Butter	175	20.2	6.15	0.46	4.97	11.6	174%
27	Margarine, low fat and reduced fat spreads	480	10.5	15.2	-	11.5	26.7	40%
28	Vegetable and salad oils	970	4.95	6.61	-	55.2	61.8	8%
29	Other fats and oils	215	4.72	3.38	-	12.3	15.7	30%
30	SUGAR AND PRESERVES	1,457	8.10	25.4	-	93.9	119	7%
31	Sugar	1,325	0.53	20.1	-	90.6	110	0%
32	Honey, preserves, syrup and treacle	132	7.57	5.2	-	3.3	8.52	89%
33	VEGETABLES	9,525	392	323	29.9	182	536	73%

No.	Food in Wales Food category	Total UK Production kt	Wales Production kt	Household Consumption Wales kt	Eating Out Consumption Wales kt	Other Consumption Wales kt	Total Consumption Wales kt	Production vs. Consumption %
34	Potatoes fresh, frozen or processed	6,636	377	146	17.0	162	325	116%
35	Vegetables, fresh, frozen or processed	2,889	14.7	177	12.9	20.0	210	7%
36	FRUIT	1,544	75.5	160	5.55	71.2	236	32%
37	Fresh fruit	328	6.27	106	1.17	37.9	146	4%
38	Fruit juices	997	56.7	40.6	2.82	15.1	58.5	97%
39	Other fruit products	218	12.4	12.9	1.56	18.2	32.7	38%
40	BREAD	2,544	35.4	123	10.9	1.31	135	26%
41	Other bread	2,544	35.4	123	10.9	1.31	135	26%
42	OTHER CEREALS AND CEREAL PRODUCTS	7,529	278	113	8.70	251	373	74%
43	Flour	3,507	48.9	8.76	0.00	159	168	29%
44	Cakes, pastries, buns, scones, etc.	981	55.8	19.7	3.94	24.9	48.5	115%
45	Biscuits	933	53.1	23.8	0.46	20.5	44.8	118%
46	Other cereals	2,106	119	60.3	4.30	47.0	111	108%
47	BEVERAGES	40.6	2.31	9.38	0.41	1.99	11.8	20%
48	Tea	-	-	6.00	0.17	0.80	6.97	0%
49	Coffee	-	-	2.31	0.24	0.64	3.19	0%
50	Drinking chocolate and branded food drinks	40.6	2.31	1.08	-	0.55	1.62	142%
51	MISCELLANEOUS	2,795	184.9	73.17	13.7	79.8	166	111%
52	Mineral water	626	35.7	26.6	4.09	20.0	50.7	70%
53	Canned soups	343	19.6	10.6	1.54	3.29	15.4	127%
54	Ice-cream and ice-cream products	443	50.9	12.4	0.92	6.06	19.4	262%
55	Other foods	1,381	78.6	23.5	7.17	50.4	81.1	97%
56	SOFT DRINKS excl. pure fruit juices	6,306	359	211	30.9	38.6	280	128%
57	Ready to drink	6,306	359	211	30.9	38.6	280	128%
58	ALCOHOLIC DRINKS	6,964	395	63.8	50.6	222	337	117%
59	Lager and Beer	5,933	337	29.1	43.0	206	279	121%
60	Wine	26.3	-	17.6	4.98	10.3	32.8	0%
61	Other alcoholic drinks	1,004	57.1	17.1	2.55	5.8	25.5	224%
62	CONFECTONARY	889.07	50.6	9.84	1.84	31.9	43.6	116%
63	Chocolate confectionary	475	27.0	6.76	1.14	16.0	23.9	113%
64	Mints and boiled sweets	100	5.73	2.46	-	2.70	5.16	111%
65	Other confectionary	313	17.8	0.61	0.71	13.21	14.5	123%
66	**Total Food and Drinks**	**56,162**	**3,197**	**1,679**	**178**	**1,205**	**3,063**	

Shaded rows are sub-totals.

Technical note: Data for the UK are from the ProdCom list 2001. Data for Welsh food production are derived by using farmland area for crops and number of livestock for meat production. Data on food consumption in Wales are derived from the National Food Survey 2000, updated with 2001 data from the ProdCom list. For further details see the methodology in the Appendix.

3.1.3 THE ECOLOGICAL FOOTPRINT OF FOOD CONSUMPTION IN WALES

The Ecological Footprint was calculated on a per capita basis for household consumption and catering services used by households, i.e. for 'eating in' and 'eating out'. Additionally, the footprint of transport of food products is provided (see Table 13).

Key findings include:

- Food consumption makes up a relatively high proportion of the total Ecological Footprint for Wales, which is 5.25 gha/cap.
- On a per capita basis, the Ecological Footprint of eating at home is 0.88 gha/cap for eating at home and 0.41 gha/cap for eating out.
- These numbers include the Ecological Footprints for the transport of food products, not only for distribution within Wales and the UK but also for the import of food from foreign countries via ship, train, lorry or aeroplane. Yet, the impact of this transportation is relatively small with 0.016 gha/cap for food eaten at home and 0.010 gha/cap for food eaten out.
- When compared with the actual amount eaten out (61 kg/cap as opposed to 578 kg/cap for food eaten at home) it becomes obvious that the footprint for eating out is disproportionally high. This is due to the fact that the service of providing food in a restaurant involves various service activities and is less efficient than food preparation at home. These 'indirect' effects are reflected in the relatively high per capita footprint for eating out.
- A large proportion of the food footprint – 44% for eating in and 26% for eating out – is due to the consumption of meat products.
- 30% of the footprint for food eaten out comes from soft drinks (10%) and alcoholic drinks (20%).

Table 13: Ecological Footprints of food consumption in Wales in 2001 (all numbers in global hectares per capita)

Food Product	EF of foods eaten in households	…thereof transport of food	EF of foods eaten out	…thereof transport of food
MILKS AND CREAMS	0.077	0.002	0.036	0.001
Liquid whole milk, full price	0.020	0.001	0.009	0.000
Skimmed milks	0.031	0.001	0.015	0.000
Other milks and dairy desserts	0.008	0.000	0.004	0.000
Yoghurt and fromage frais	0.010	0.000	0.004	0.000
Cream	0.009	0.000	0.004	0.000
CHEESE	0.022	0.000	0.010	0.000
Cheese, natural	0.019	0.000	0.009	0.000
Cheese, processed	0.003	0.000	0.002	0.000
MEAT	0.341	0.001	0.159	0.001
Beef and Veal	0.034	0.000	0.016	0.000
Mutton and Lamb	0.023	0.000	0.011	0.000
Pork	0.044	0.000	0.021	0.000
Bacon and Ham, uncooked	0.028	0.000	0.013	0.000
Bacon and Ham, cooked including canned	0.033	0.000	0.015	0.000
Poultry, uncooked	0.107	0.000	0.050	0.000
Poultry, cooked not canned	0.014	0.000	0.006	0.000
All other meat and meat products	0.057	0.000	0.027	0.000
FISH	0.051	0.000	0.024	0.000
Fresh fish	0.007	0.000	0.003	0.000
Processed and shell	0.003	0.000	0.001	0.000
Prepared, including fish products	0.026	0.000	0.012	0.000
Frozen, including fish products	0.014	0.000	0.007	0.000
EGGS	0.034	0.000	0.016	0.000
FATS AND OILS	0.042	0.001	0.019	0.000
Butter	0.009	0.000	0.004	0.000
Margarine, low fat and reduced fat spreads	0.006	0.000	0.003	0.000
Vegetable and salad oils	0.016	0.000	0.007	0.000
Other fats and oils	0.010	0.000	0.005	0.000
SUGAR AND PRESERVES	0.012	0.001	0.006	0.000
Sugar	0.011	0.001	0.005	0.000
Honey, preserves, syrup and treacle	0.002	0.000	0.001	0.000
VEGETABLES	0.041	0.003	0.019	0.001
Potatoes fresh, frozen or processed	0.022	0.001	0.010	0.001
Vegetables, fresh, frozen or processed	0.019	0.001	0.009	0.001
FRUIT	0.030	0.003	0.014	0.001
Fresh fruit	0.019	0.002	0.009	0.001
Fruit juices	0.006	0.001	0.003	0.000
Other fruit products	0.005	0.000	0.002	0.000
BREAD	0.019	0.001	0.009	0.000
Other bread	0.019	0.001	0.009	0.000
OTHER CEREALS AND CEREAL PRODUCTS	0.057	0.002	0.027	0.001

Food Product	EF of foods eaten in households	…thereof transport of food	EF of foods eaten out	…thereof transport of food
Flour	0.016	0.001	0.007	0.000
Cakes, pastries, buns, scones and tea cakes	0.012	0.000	0.006	0.000
Biscuits	0.007	0.000	0.003	0.000
Other cereals	0.023	0.001	0.011	0.000
BEVERAGES	0.006	0.000	0.003	0.000
Tea	0.003	0.000	0.001	0.000
Coffee	0.003	0.000	0.001	0.000
Cocoa and drinking chocolate and branded food drinks	0.001	0.000	0.000	0.000
MISCELLANEOUS	0.038	0.001	0.018	0.000
Mineral water	0.001	0.000	0.001	0.000
Soups, canned, dehydrated and powdered	0.007	0.000	0.003	0.000
Ice-cream and ice-cream products	0.006	0.000	0.003	0.000
Other foods	0.024	0.001	0.011	0.000
SOFT DRINKS excl pure fruit juices	0.039	0.001	0.018	0.001
Ready to drink	0.039	0.001	0.018	0.001
ALCOHOLIC DRINKS	0.059	0.002	0.028	0.001
Lager and Beer	0.020	0.001	0.010	0.001
Wine	0.018	0.000	0.009	0.000
Other alcoholic drinks	0.021	0.000	0.010	0.000
CONFECTONARY	0.011	0.000	0.005	0.000
Chocolate confectionary	0.008	0.000	0.004	0.000
Mints and boiled sweets	0.001	0.000	0.000	0.000
Other confectionary	0.003	0.000	0.001	0.000
Total Food and Drinks	**0.879**	**0.018**	**0.411**	**0.009**

(The grey lines are subtotals)

3.2 Policy Implications

3.2.1 WELSH POLICY CONTEXT

Agriculture and food processing play a pivotal role in shaping the environment, economy and social fabric of rural Wales: it supports more than 10 per cent of full-time equivalent employees across the country; has created the traditional appearance of the Welsh countryside; and has defined the character of Welsh rural society and its sense of identity. Alongside these developments however, negative trends have evolved: farmers are heavily reliant on subsidies which represent up to 98 per cent of net farm income; monoculture and heavy grazing have contributed to a loss in biodiversity; and the typical family farms are being transformed to either larger units or smaller part-time farms[13].

Food is also a basic life necessity that determines quality of life, a fact that is no less important to the population of Wales. Health in Wales compares poorly with that in many other European countries, and is consistently worse than in England[14]. In 2001, 42 per cent of deaths in Wales were due to diseases of the circulatory system, 26 per cent were due to cancer and 12 per cent were due to diseases of the respiratory system[15]. There are also substantial inequalities in health between different communities in Wales, with death rates being highest in those areas experiencing the highest levels of social and economic deprivation[2].

In order to tackle these issues effectively the WAG have developed, and are implementing, a number of strategies. In terms of food production across Wales 'Farming for the Future: A new direction for farming in Wales' (2003) sets a new vision of an innovative agri-food industry, creating high quality, value added food products while at the same time enhancing the biodiversity of the Welsh countryside, supporting tourism and the survival of the Welsh family farm. This is further supported by the Wales Agri-Food Partnership, which brings together the Dairy, Organic and Lamb and Beef sectors, ensuring the development of a whole-chain approach to the industry. One of the many achievements has been the establishment of action plans for each of these three sectors.

At the consumption end of the scale the WAG has also developed integrated national and local policies and programmes to promote a healthier diet and reduce inequalities in health. This is largely being implemented through 'Food and Well Being: Reducing inequalities through a nutrition strategy for Wales' (2003) which has an overall aim to improve the diet of all people in Wales with a special emphasis on key population groups.

3.2.2 KEY POLICY OBJECTIVES & TARGETS

The establishment of a 'Second Organic Action Plan for Wales 2005 – 2010' (2004) reflects a goal which is consistent with the Assembly's vision for a sustainable Welsh agriculture as expressed in the 52 action points of 'Farming for the Future', and with the evolving reform of European agricultural policy[16]. It is also consistent with the Welsh Nutrition Strategy, with its emphasis on improving diets, nutrition and health. The action plan sets out 58 recommendations under eight core themes, contributing to one main target (See Table 14):

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[13] Farming for the Future: A new direction for Farming in Wales (2001) WAG

[14] Food and Well Being: Reducing inequalities through a nutrition strategy for Wales (2003) Food Standards Agency & WAG

[15] Health Statistics Wales (2003), WAG

[16] Second Organic Action Plan for Wales 2005-2010 (2004) Agri-Food Partnership Organic Strategy Group

Table 14: Summary of recommendations outlined in the Second Organic Action Plan for Wales 2005-2010.

Summary of Organic Action Plan Recommendations
TARGET: 10%-15% of agricultural land in Wales to be organic or in-conversion by the end of 2010.
RECOMMENDATIONS:
1. Environmental payments: In recognition of the environmental benefits provided by organic agriculture, the WAG should continue to provide organic farmers with conversion aid and maintenance payments in order to support the growth of land under organic management to 10–15% by 2010. It is recognized that the market needs to be developed in line with production (see 2).
2. Developing the market: The WAG and the Welsh Development Agency (WDA) should support the work of Organic sector businesses and work with them, Meat Promotion Wales/Hybu Cig Cymru (HCC) and key multiple and independent retailers to help promote and develop the market for Welsh organic products. The WAG and the WDA should also encourage the sustainable procurement of organic food, locally produced where possible, by schools, hospitals, universities and other public authorities, starting with pilot projects in 2004.
3. Develop new marketing and processing opportunities: by focusing on the quality of our food offer and building on WDA and Wales Tourist Board activities to establish and market a quality food culture in Wales. This includes tourism, the hospitality sector and the food service sector.
4. Public education: Develop a targeted public education campaign to increase awareness of organic farming, including schools and health related work, promotional information and factual information for consumers, drawing on best practice from other member states.
5. Public health: Increase awareness of the links between diet, nutrition and health through working with young people and those having contact with the health services such as pregnant mothers, elderly persons and those suffering from illness. The Organic Strategy Group will engage with the agencies involved in health education in Wales in order to stress commonality of message and interests.
6. Research, market intelligence: The WAG, through liaison with DEFRA, should ensure that account is taken of specific Welsh needs in funding and the focus of research. Through Organic Centre Wales (OCW) and other stakeholders, identify statistics and market intelligence needs and develop projects to meet these needs, ensuring desegregation to a Welsh level when appropriate.
7. Minimise the administrative load: Producers are increasingly burdened with proving their compliance with assurance and agri-environment schemes and ever-increasing legislative requirements. Through liaison with the WAG, OCW will work to ensure streamlining of schemes and verification inspections.
8. GM-free Wales: The Organic Strategy Group wishes to see Wales' GM-free status maintained.

While organic farming may be one of several approaches to delivering the policy goals set out in 'Farming for the Future' and 'Food and Well Being', it is the only approach that is seriously attempting to address all of them simultaneously, representing the spirit of the European model of a multi-functional agriculture, based on an eco-farming system approach to its delivery[4].

'Food and Well Being' contains nine recommendations and a series of associated actions for key players deemed responsible for the implementation of the strategy including, the Welsh Assembly Government, the Food Standards Agency Wales, local authorities, local health boards, Wales Centre for Health, schools, universities, the voluntary sector, and food retailers and producers. The recommendations are listed in Table 15.

Table 15: Summary of recommendations set out in 'Food and Well Being: Reducing inequalities through a nutrition strategy for Wales'.

Summary of Nutrition Strategy Recommendations
Recommendations:
1: Increase the uptake of a healthy balanced diet among the general population, especially among the identified priority groups, with an emphasis on tackling food equality priorities, to help ensure that nutrient and micronutrient levels meet recommended values.
2: Increase fruit and vegetable intake among the general population, especially among the priority groups.
3: Develop and manage initiatives to prevent and manage overweight and obesity among the population.
4: Ensure that national schemes and policies are in place to assist improvements in healthy eating.
5: Provide information and training to key players, including policy decision makers, health professionals and other professionals, to tackle poor nutrition in Wales
6: Ensure that the public is well informed about nutrition and the need for dietary improvement, especially those belonging to the identified priority groups.
7: Ensure that appropriate local initiatives are in place to tackle the main barriers to improving nutrition.
8: Develop and promote initiatives with the food industry to improve healthy eating, especially initiatives relating to access to specific foods.
9: The impact of activities resulting from the strategy are evaluated.
Targets:
1: Knowledge of recommended number of portions of fruit and vegetables, and correct estimation of a portion size will increase by 10% from 31% by 2005, particularly among low-income groups (20%).
2: Perception of access as a barrier to a healthy diet by low income and other vulnerable groups will decrease by 10% from 38% by 2010.
3: Average daily intake of fruit and vegetables will increase by 10% from 3.1 portions per day for the general public by 2010, with most increase for low income and vulnerable consumers.
4: The balance of the diet will come closer to government recommendations among all priority groups from 2010, relative to baseline data.

3.2.3 ECOLOGICAL FOOTPRINT IMPLICATIONS

It is clear that if the targets laid out in Table 14 and Table 15 are met, Wales would experience a shift in current food production and consumption patterns. These changes would undoubtedly have an impact on the current Ecological Footprint of food. Greater consumption of food from low energy input farming systems (i.e. organic cultivation) and local farms will certainly bring about a reduction in the Footprint, as would a change in the composition of diets. However, it is necessary to establish clearly which of these factors have the potential to instigate the greatest reduction within the context of current Welsh policy and limitations. In the following section two scenarios have been developed based on the targets and recommendations listed in Table 14 and table 15. The first scenario investigates the potential impact the nutrition strategy could have on the diet of a young school child and how this would affect the food Footprint. The second scenario assesses the impact of organic food production and consumption policies on the Ecological Footprint. The findings should determine whether current food production and nutrition policies will be effective enough to bring about a significant change to the current Ecological Footprint of food in Wales.

3.3 Future Scenarios

3.3.1 KEY SCENARIO INDICATORS

The key scenario indicators chosen for the analysis are dietary composition, based on the policies set out in 'Food and Well Being' and the production of organic food as targeted in the 'Second Organic Action Plan for Wales'. This section will investigate and assess the impact of these policies on the Ecological Footprint of food in Wales.

3.3.2 THE ECOLOGICAL FOOTPRINT OF DIFFERENT DIETS

The present scenario explores the potential impact of the various policies and programs introduced to instigate the nine recommendations laid out in 'Health and Well Being'. Children and young people are one of a number of priority groups identified in the nutrition strategy, with this in mind they have been chosen as a case study for this scenario. Three diets have been identified relating to primary school aged children: the first diet would be classed as being of poor nutritional value, while the second and third represent diets which have been influenced, to various degrees, by policies implemented through 'Health and Well Being.' They are as follows:

Diet 1 – Dewi

Dewi is an 8 year old primary school boy who would be considered as having a poor nutritional diet. He is often in a rush to get to school in the morning and so tends to skip breakfast. When he does have the time for breakfast he usually has a slice of white toast with chocolate spread and a glass of orange squash. During the morning break at school Dewi buys a packet of crisps and a can of fizzy drink from the tuck shop. Dewi has school dinners and almost always opts for chips and the pre-prepared meal (i.e. fish fingers, chicken Kiev's, sausage rolls, pasties etc) with plentiful sauces (e.g. ketchup, mayonnaise) and frequently declines fresh vegetables. Cakes are his preferred dessert. In the afternoon he may buy another fizzy drink and nibble on a packet of sweets. Back at home Dewi will snack on biscuits and chocolate bars until his parents, who work long hours, prepare a quick easy ready meal (e.g. lasagne, curry) or bring home a take away (e.g. Pizza, Chinese).

Diet 2 - Gareth

Nutrition strategy programmes in place at school:
School Breakfast
Fresh Water Dispensers
Increased Fruit and Vegetable in School Meals
Fruit Tuck Shop
School Nutrition Campaign – Nutrition and Cooking Skills and Healthy Eating Resources
Free School Milk

Gareth is also an 8 year old boy. Over the last year his school has been implementing a very diverse nutrition strategy that is having an impact on his diet. Gareth also used to struggle to eat breakfast in the morning but now has it at school. He alternates between having cereal (with a high fibre content) and wholemeal toast with yoghurt and fresh fruit juice. He is always encouraged to have the fruit option, which he takes on average twice a week. During the morning break Gareth buys fruit from the tuck shop and has it with a glass of milk. The school has reformed the type of meals it serves at lunch times and only offers one pre-prepared meal a week. Chips are now seldom on the menu. Instead, the school serves more fresh fish, a greater selection of vegetables and salads and home-made fruit based desserts. Fresh juice is always offered and Gareth has access to an unlimited supply of drinking water from the several dispensers around the school. Gareth spends a couple of hours each week developing his cooking skills and knowledge of nutrition through the school's nutrition campaign. He is aware of the health benefits associated with healthy eating and is learning that cooking does not necessarily have to be a chore. He has learnt to make some quick, simple and inexpensive small meals that he attempts to repeat at home. His mum has also been attending community cooking classes and makes a concerted effort to cook a meal with the required average daily intake of fruit and vegetables at least four days a week. Red meat, chicken and fish are consumed twice weekly.

Diet 3 – Patrick

Extra initiatives on top of the nutrition program outlined in diet 2:
Local Food Sourcing Initiative
20% Organic Produce
Grow your own scheme – School Allotment
Community Cooking Classes

Patrick's school has been implementing the same diverse nutrition strategy, with a few extra policies. Where possible the school only purchases locally grown fresh produce and has a target to serve 20 per cent organic food at all meals. It does not sell any confectionary snacks or fizzy drinks. Milk and fresh juice is organic and water is available at all times. As well as attending cooking classes Patrick is involved in the daily running of the schools' allotment and often takes fresh produce home for his parents to prepare for dinner. Patrick does not eat any red meat and will only consume organic chicken and fresh fish. At home 20 per cent of the fresh produce bought is organic and his parents only buy seasonal fruit and vegetables of which consumption has increased by 15%. Ready meals are never bought.

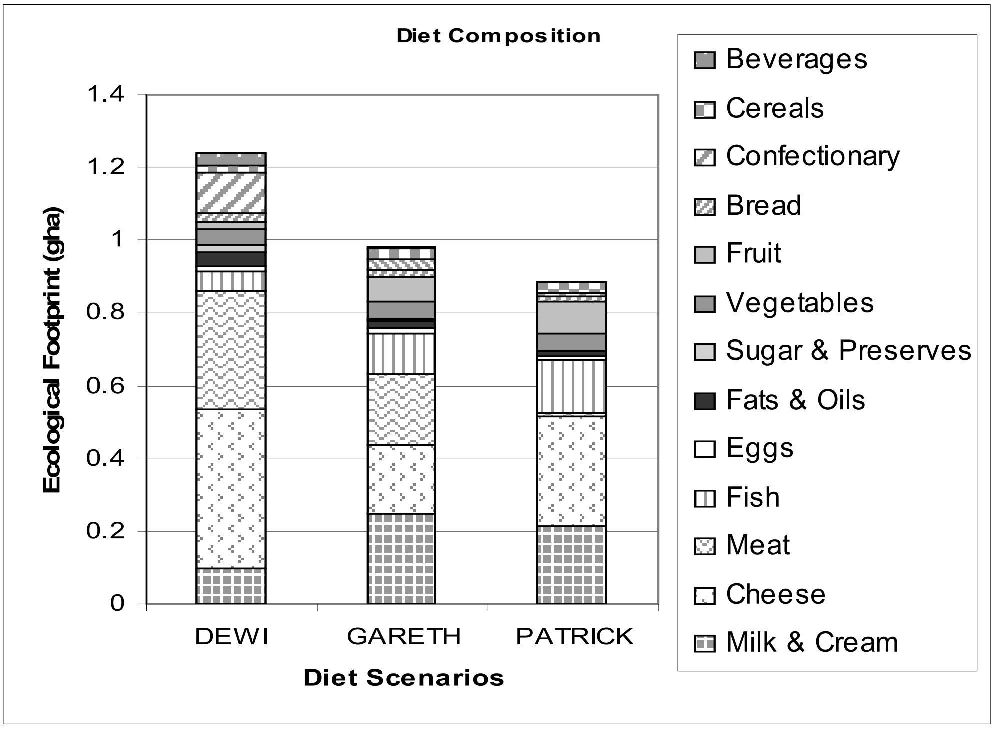

Figure 7: The potential impact of a successful nutrition strategy implementation on the diet composition of primary school children and their associated Ecological Footprint.

Figure 7 depicts the positive impact the nutrition strategy would have on the Ecological Footprint of food. The potential reduction made with the above modelled diets is from 1.24 gha to 0.89gha (a footprint reduction of almost 30%). 'Health and Well Being' therefore has the potential to not only have the direct health benefits it sets out to achieve but could also indirectly contribute to ecological sustainability.

In conclusion, the results suggest that a healthy diet will usually have a low Ecological Footprint. This demonstrates a policy option that has the ability to both improve the quality of life of specific groups with poor nutritional diets whilst at the same time reducing the Ecological Footprint.

3.3.3 Organic food production and consumption – the impact of different policies

On the basis of the present state of the Welsh market in organic food, scenarios for the situation up to and in the year 2020 have been developed in order to investigate how certain policies and developments will affect the Ecological Footprint of food production and consumption. The time frame of 15 years was chosen because it allows modelling of a possible future situation whilst accommodating for factors such as the time required for conversion to full organic status and some changes in consumer behaviour.

Scenarios for future organic food production

Scenario outline

The area of organically managed farmland in Wales has increased significantly from less than 1 per cent in 1998 to 4 per cent or 58,000 ha in 2002. A similar development has taken place in the whole of the UK where 4.3 per cent of farmland was organically managed in 2002. However, in both the UK and Wales, the rise in the share of organic farmland stagnated at 4% in the past few years. Data for Wales are shown in Table 16.

Table 16: Past development of organically managed farmland in Wales

Year	Organic farmland area Ha	Share of total farmland area %
1998	7,300 [a)]	0.5% [a)]
1999	19,000 [a)]	1.3% [a)]
2000	33,500 [a)]	2.3% [a)]
2001	42,000	2.9%
2002	58,100	4.0%
2003	58,300	4.0%
2004	58,300	4.0%

a) estimated area using UK data
Numbers include land area in conversion to organic farming.
Data sources: Soil Association, Organic Food and Farming Reports 1998 to 2003 and Organic food: facts and figures 1998 to 2004; Defra, 2004, Organic Statistics United Kingdom (http://statistics.defra.gov.uk/esg/statnot/orguk.pdf)

In order to assess the possible future developments of organic food production in Wales three different scenarios have been constructed. The development of the share of organic farmland in these scenarios is depicted in Figure 8.

- **Scenario A ("Status Quo")**: assumes that there is no further growth in the production of organic food. This scenario is based on the fact that for the past three years the share of organically managed farmland stagnated at 4 per cent. This stagnation could continue if there is no further growth in demand and no further incentives from policy initiatives.
- **Scenario B ("WOS Target")**: adopts the target from the Welsh Organic Strategy that 10 to 15 per cent of agricultural production should be organic by 2010 (the average of 12.5% has been chosen for calculations). It assumes that there is no further growth of organic production after 2010.
- **Scenario C ("Ambitious Strategy")**: adopts the upper level of 15 per cent organic food production by 2010 from the Welsh Organic Strategy and assumes that a further growth to 30 per cent by 2020 can be sustained through ambitious policies to promote organic agriculture and food consumption.

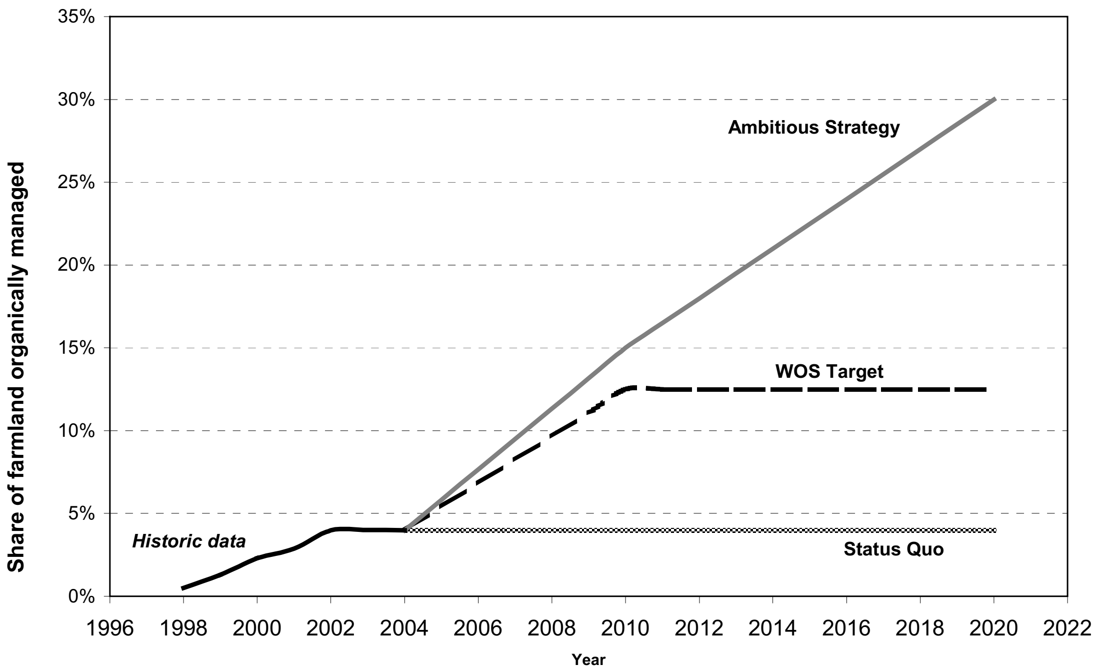

Figure 8: Development of organic food production in Wales as outlined in three scenarios

Assumptions and methodological issues for estimating the Footprint for organic food

For all calculations it was assumed that the actual production of organic food is proportional to the farmland area. The total farmland area – and therefore total amount of food produced – was assumed to remain constant over time. Furthermore, it has been taken into account that on UK average there is a disproportionately higher production of meat products and eggs, with 1.5 and 9 times the average level of organic food production, respectively. No data was available for the production of organic fish. It was assumed to be the same as the average of all organic food production.

Two components make up the footprint for food: real land requirements (such as crop land, pasture land, sea area) and energy land requirements. It was assumed that organic food production requires the same land area as the production of conventional food. In reality, organic agriculture is likely to have lower yields per hectare because of its extensive character; hence real land requirements are likely to be higher. However, no reliable data on this issue could be made available and therefore the conservative assumption of equal land requirements for both organic and conventional food production was adopted.

The energy component of the footprint was split in two parts: embodied energy for *producing* and embodied energy for *processing* the food. The first part encompasses the energy required to produce the raw material (e.g. wheat), while the second part includes all energy required to turn the raw material into the final product (e.g. bread). Data on the embodied energy of conventional produce in the Netherlands have been collected in the context of the Energy Analysis Program (EAP[17]). Since similar data are not available for the UK at present, those for the Netherlands were used.

For the organic production of raw materials figures were obtained from a report on 'Energy use in organic farming systems' (ADAS, 2000[18]), which lists the energy inputs of conventional and organic farm produce in the UK (in MJ/kg) covering arables, vegetables, upland livestock and dairy. It includes inputs of fertilisers, pesticides, machinery and any transport up to the farm gate. The embodied energy of organic farm produce was calculated as a percentage of the embodied energy of conventional produce.

For the processing of organic food the figures used to calculate the embodied energy of conventional production were applied due to the lack of more specific data. The use of the same figures in both cases is justified, as it cannot be assumed that the production of organic food requires less energy than that of conventional food.

On average, the *production* of organic raw food materials requires 67% less energy than conventional methods. However, as *processing* this food is assumed to be as energy intensive as processing conventional food, the overall energy footprint for organic food is only 17% lower than the one for conventional food.

Results for future organic food production

The Ecological Footprints for the three scenarios of food production have been calculated. Please note, that the resulting footprints relate to *production* and not *consumption* of food. Therefore, the results are given in absolute numbers for Wales as a whole and have not been converted into per capita figures. Also, the production footprints were not standardised like the consumption footprints. The results are shown in Figure 9.

The potential reduction of the Ecological Footprint through increased production of organic food is generally low. For example, if the ultimate aim of the 'Ambitious Strategy' to increase organic food production to 30 per cent were to be achieved, the total footprint would drop by 10 per cent from 6.6 million global hectares (Mgha) to 5.9 Mgha. The reason for this modest decrease is that organic farming needs the same or even more land area than conventional farming, although there is a significant saving in energy consumption. For the example above, the energy to *produce* the organic food would drop by 24 per cent, while the land area as well as the energy to *process* the food would roughly remain the same. It should be mentioned that other, positive effects of organic farming like

[17] Wilting, H.C., Benders, R.M.J., Biesiot, W., Louerd, M., Moll, H.C. (1999), EAP – Energy Analysis Program, Interfacultaire Vakgroep Energie en Milieukunde (IVEM), Onderzoeksrapport No. 98

[18] ADAS Consulting Ltd. (2000), Energy use in organic farming systems, MAFF Project Code: OF0182

the absence of pesticides and synthetic fertilisers or improved conditions for soils and insects, are not picked up by the Ecological Footprint.

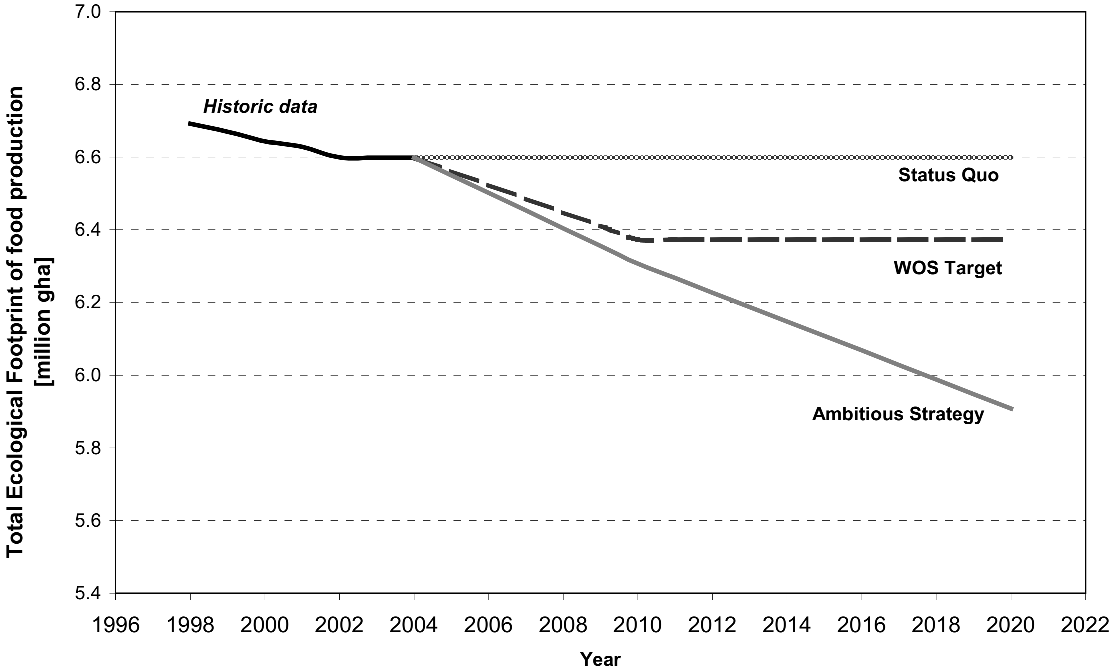

Figure 9: Ecological Footprint for three scenarios of organic food production in Wales

Scenarios for future organic food consumption

In this section we explore the impact of increased organic food consumption, questioning how well organic food production and consumption in Wales fit together, and where potentials for the reduction of imports are possible. The obvious advantage of consuming local food relates to reduced transport distances and greater control over the standards of production.

No Welsh specific data for organic food consumption was available and therefore UK data had to be used instead. Table 17 shows the past development of the market for organic food in the UK. Starting from a share of just 0.5 per cent in 1998 the organic food market has grown immensely in the past six years and in 2003 organic food sales reached 1.3 per cent of the total market sales. Growth rates reached a climax of over 50 per cent in 2000 and have slowed down since to a level of 7.9 per cent in 2003.

The organic livestock sector is experiencing the greatest growth and this looks set to continue. The rate of conversion of upland farms means that the supply of organic store animals will increase considerably, along with the requirement for organic feed cereals. In contrast, the rate of growth in organic cropping has been slower.

Table 17: Past development of organic food sales in the UK

Year	Organic food sales	Total final demand for food	Organic food sales as share of final demand	Annual increase	Share of imports
	m£	m£	%	%	%
1998	350	69,567	0.50%		
1999	390	72,482	0.54%	7.0%	70%
2000	605	74,110	0.82%	51.7%	75%
2001	802	76,020	1.05%	29.2%	70%
2002	920	77,742 [a)]	1.18%	12.2%	65%
2003	1015	79,511 [a)]	1.28%	7.9%	56%

a) trend estimate using a linear regression over the years 1999 to 2001
Data sources: Soil Association, Organic Food and Farming Reports 1998 to 2004; Office for National Statistics 2003, United Kingdom Input-Output Analyses, 2003 Edition. Table download at: http://www.statistics.gov.uk/inputoutput

A majority of organic food products is imported. Imports accounted for 75 per cent of the organic food market in 2000 but have dropped since to 56 per cent in 2003. The import of organic meat is relatively low at just over 4 per cent but more than 80 per cent of all organic fruit and vegetables sold in the UK are imported.

Predicting the future market for organic food is difficult for a number of reasons. As testified by DEFRA (2003)[19], "Despite the recent dramatic growth rates, organic still represents a small proportion of the total food sector, and many factors influence supply and demand. Predicting and managing growth in these conditions is difficult. A small increase in the number of producers in one sector can result in a significant increase in available organic product, leading to significant pressure on prices and loss of confidence by existing organic farmers and those considering conversion."

The domestic market for organics is also influenced by the market situation both within the European Union and further abroad as well as exchange rates (DEFRA, 2003b[20]). Government policies are widely regarded as having an important effect on market development (Padel, S. et al., 2003:8[21]) as are food scandals (Ibid., 2003:13-14[22]), although both may play an ambiguous role, either increasing or decreasing demand. However, there seems to be the potential for sustained growth of the organic food market (IGD, 2002[23]). As testified by the Welsh Agri-Food Partnership Organic Strategy Group (2004) the Welsh government also aims to support growth in this market (2001).

To take account of the influence such factors have on market development and to show different possible routes of growth in organic food consumption in Wales, three distinct scenarios were developed (see Figure 10 for illustration):

- **Scenario A ("Slowing Growth")**: assumes that the downward trend in the growth of the organic food market continues and that growth decreases slowly and comes to a halt in the year 2020. Organic food sales would then have reached only 2.4% of the total food market. This scenario could happen if no further incentives for organic food production and consumption are provided.

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[19] Department for Environment, Food and Rural Affairs (DEFRA) (2003a), Action Plan to Develop Organic Food and Farming in England, http://www.defra.gov.uk/farm/organic/actionplan/actionplan.htm

[20] Department for Environment, Food and Rural Affairs (DEFRA) (2003b), England's Organic Sector: Prospects for Growth, http://www.defra.gov.uk/farm/organic/actionplan/prospects.htm

[21] Padel, S., Seymour, C., Foster, C. (2003), Organic marketing initiatives and rural development, Project code QLK5-2000-01124, http://www.irs.aber.ac.uk/OMIaRD/publications.pdf/Delphi_Final_Report_Oct_2003_D.pdf

[22] Same reference as footnote 9

[23] IGD (2002), Organic Action Plan – The size of the UK grocery/organic market, (Project code: ORG 61) www.defra.gov.uk/farm/organic/introduction/org61.pdf

- **Scenario B ("Sustained Growth")**: assumes that the current growth rate of 7.9% for organic food can be sustained over the next one and a half decades. This is close to the estimates of a majority of experts in a survey that formed part of a larger study of the organic markets in a number of European countries (Padel et al. 2003:24).
- **Scenario C ("High Growth")**: assumes that – through ambitious policies, programmes and campaigns – the growth in organic food sales can regain strength and result in a second climax of 30% in 2010 while losing momentum after that and dropping to 0% in 2020. Organic food would reach a market share of 16% in 2020 in this scenario.

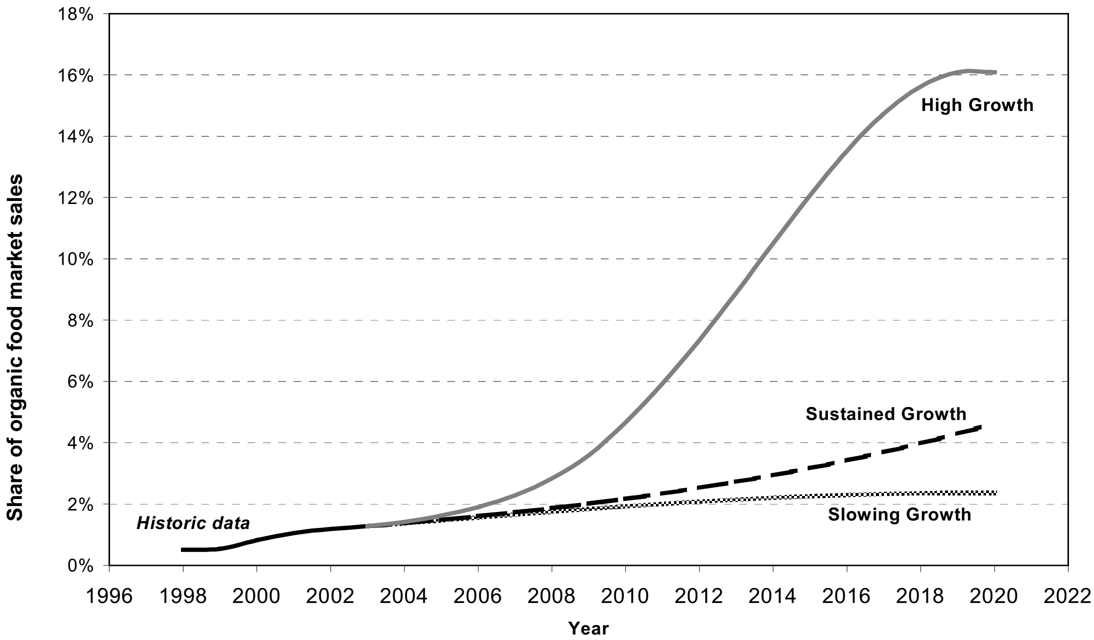

Figure 10: Development of organic food market sales in Wales as outlined in three scenarios

The Ecological Footprints for these three scenarios have been calculated on a per capita basis under the assumptions that actual consumption is proportional to organic food sales and that the total amount of food eaten per person remains constant. A summary of the results is shown in Table 18. While the increase in the amount of organic food consumed is obvious, the decrease in the Ecological Footprint is small because savings in energy of food production are relatively low when compared to energy requirements of food processing and land requirements which remain the same.

Table 18: Results for three scenarios of organic food consumption in Wales

	Baseline	**Scenario a "Slowing Growth"**	**Scenario b "Sustained Growth"**	**Scenario c "High Growth"**
Year	2001	2020	2020	2020
Organic food market share	1.05%	2.2%	4.6%	16%
Individual food footprint [a)]	1.29 gha/cap	1.28 gha/cap	1.27 gha/cap	1.21 gha/cap
% change to baseline		-0.51%	-1.4%	-5.9%
Total amount of organic food consumed	29,900 t	69,000 t [b)]	135,400 t [b)]	470,500 t [b)]

a) combined footprint of eating in and eating out

b) takes into account the predicted growth in Welsh population

Supply and demand for organic food in Wales – now and in the future

The material flows of organic food production and consumption have been estimated by using data obtained in the material flow analysis (MFA) described in section 4.1.

In 2001, organic food *production* was 2.9 per cent of all food production in Wales (based on the share of organically managed farmland, see Table 19). This is slightly below the UK average of 3.2 per cent. As there is not detailed information on individual food products it had to be assumed that this share holds true for all products except for those where the value of organic sales suggest that there is a higher or lower than average production rate. This is the case for meat and eggs (higher) and cereals (lower). In order to illustrate a likely situation in 2020 the 'medium' scenario for food production (Scenario B: "WOS Target") was chosen.

The average share of organic food *consumption* in 2001 was 1.1 per cent. This is based on a more detailed breakdown by eight food categories (Soil Association; Organic Food and Farming Report 2002). Scenario c ("High Growth") was chosen for comparison as it is likely to demonstrate the upper boundary of organic food consumption in 2020.

The results from the MFA are shown in Table 19. In 2001 the production of organic food in Wales on average exceeds consumption by a factor of 3. The analysis suggests that for some food product groups such as dairy products, cereal products or beer, production is much higher than consumption while other products such as certain meat types, fish, sugar or fruits, clearly have to be imported to satisfy Welsh demand (it has to be born in mind that all values in Table 19 are estimates with a likely error margin of up to 50%). This suggests that for a majority of food products it should be possible in theory to 'close the trade gap' and to satisfy local demand through supply from local or regional sources. This is particularly important for organic food where still more than half of all products are imported from other countries (imports account for 56% of all organic food sales in 2003[24]).

In the future there needs to be an increase in production in order to satisfy the growing demand for organic food. A modest increase in production – depicted by the Scenario B "WOS Target" – would still be able on average to satisfy 92 per cent of the high demand as assumed in Scenario C "High Growth". However, the margin of oversupply in some food categories would shrink and undersupply in others categories would increase (see Table 19). Some of these discrepancies could be alleviated by supporting certain production sectors (like the production of organic pork meat, for example) which would encourage local sourcing. For other product groups, such as tropical fruits, this would be much less feasible.

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Table 19: Estimated amounts of organic food produced and consumed in Wales in 2001 and 2020

Food category	Production of organic food in 2001	Scenario "WOS Target" for the production of food in 2020	Consumption of organic food in 2001	Scenario "High Growth" for the consumption of food in 2020	Production versus consumption of organic food in 2001	Scenario production versus consumption of organic food in 2020
	tonnes	tonnes	tonnes	tonnes	%	%
	2.9% of all food produced is organic	12.5% of all food produced is organic	1.1% of all food consumed is organic	16% of all food consumed is organic		
MILKS AND CREAMS	25,359	109,305	2,939	46,210	863%	237%
Liquid wholemilk	7,710	33,234	936	14,710	824%	226%
Skimmed milks	12,616	54,378	1,462	22,989	863%	237%
Other milks and dairy desserts	2,083	8,980	193	3,035	1079%	296%
Yoghurt and fromage frais	1,353	5,830	197	3,102	685%	188%
Cream	1,597	6,884	151	2,374	1058%	290%
CHEESE	1,724	7,431	268	4,214	643%	176%
Cheese, natural	1,437	6,193	228	3,587	630%	173%
Cheese, processed	287	1,238	40	627	720%	197%
MEAT	17,231	74,270	8,692	136,642	198%	54%
Beef and Veal	2,749	11,848	922	14,501	298%	82%
Mutton and Lamb	2,573	11,090	596	9,369	432%	118%
Pork	211	911	490	7,698	43%	12%
Bacon and Ham, uncooked	91	393	584	9,182	16%	4%
Bacon and Ham, cooked including canned	217	933	418	6,575	52%	14%
Poultry, uncooked	4,502	19,405	1,663	26,149	271%	74%
Poultry, cooked not canned	2,253	9,711	565	8,886	399%	109%
All other meat and meat products	4,635	19,980	3,453	54,282	134%	37%
FISH	248	1,069	354	5,562	70%	19%
Fresh fish	90	388	51	809	175%	48%
Processed and shell	5.2	22.3	16.6	261.0	31%	9%
Prepared, including fish products	115.4	497.6	190.3	2,992.4	61%	17%
Frozen, including fish products	37.4	161.4	95.5	1,502.1	39%	11%
EGGS	5,646	24,337	801	12,593	705%	193%
FATS AND OILS	1,171	5,049	1,086	17,072	108%	30%
Butter	585	2,522	109	1,709	538%	148%
Margarine, low fat and reduced fat spreads	306	1,318	250	3,937	122%	33%
Vegetable and salad oils	144	619	580	9,115	25%	7%
Other fats and oils	137	590	147	2,311	93%	26%
SUGAR AND PRESERVES	235	1,012	1,119	17,596	21%	6%
Sugar	15.4	66.2	1,039.3	16,338.6	1%	0%
Honey, preserves, syrup and treacle	219.5	946.2	80.0	1,257.0	275%	75%

Food category	Production of organic food in 2001	Scenario "WOS Target" for the production of food in 2020	Consumption of organic food in 2001	Scenario "High Growth" for the consumption of food in 2020	Production versus consumption of organic food in 2001	Scenario production versus consumptio n of organic food in 2020
	tonnes	tonnes	tonnes	tonnes	%	%
	2.9% of all food produced is organic	12.5% of all food produced is organic	1.1% of all food consumed is organic	16% of all food consumed is organic		
VEGETABLES	11,382	49,061	5,033	79,122	226%	62%
Potatoes fresh, frozen or processed	10,955	47,221	3,055	48,028	359%	98%
Vegetables, fresh, frozen or processed	427	1,840	1,978	31,095	22%	6%
FRUIT	2,189	9,436	2,224	34,965	98%	27%
Fresh fruit	182	783	1,368	21,506	13%	4%
Fruit juices	1,646	7,096	549	8,635	300%	82%
Other fruit products	361	1,557	307	4,824	118%	32%
BREAD	1,029	4,433	318	4,994	324%	89%
Other bread	1,029	4,433	318	4,994	324%	89%
OTHER CEREALS AND CEREAL PRODUCTS	6,798	29,302	875	13,762	777%	213%
Flour	1,197	5,158	394	6,202	303%	83%
Cakes, pastries, buns, scones, etc.	1,367	5,893	114	1,792	1200%	329%
Biscuits	1,300	5,602	105	1,654	1235%	339%
Other cereals	2,934	12,648	262	4,114	1121%	307%
BEVERAGES	67.0	288.7	163.2	2,565.7	41%	11%
Tea	0.0	0.0	96.6	1,518.0	0%	0%
Coffee	0.0	0.0	44.2	694.2	0%	0%
Drinking chocolate and branded food drinks	67.0	288.7	22.5	353.6	298%	82%
MISCELLANEOUS	5,361	23,109	1,565	24,596	343%	94%
Mineral water	1,035	4,461	476	7,481	218%	60%
Canned soups	567	2,444	145	2,277	391%	107%
Ice-cream and ice-cream products	1,479	6,374	182	2,867	811%	222%
Other foods	2,281	9,830	761	11,971	300%	82%
SOFT DRINKS excl. pure fruit juices	10,410	44,872	3,891	61,176	268%	73%
Ready to drink	10,410	44,872	3,891	61,176	268%	73%
ALCOHOLIC DRINKS	9,795	42,220	192	3,016	5106%	1400%
Lager and Beer	9,795	42,220	159	2,494	6174%	1693%
Wine	0	0	19	293	0%	0%
Other alcoholic drinks	0	0	15	229	0%	0%
CONFECTIONARY	1,468	6,326	409	6,430	359%	98%
Chocolate confectionary	784	3,380	224	3,524	350%	96%
Mints and boiled sweets	166	716	48	762	343%	94%
Other confectionary	517	2,230	136	2,145	379%	104%
Total Food and Drinks	**100,113**	**431,523**	**29,929**	**470,515**	**335%**	**92%**

The values in grey are sub totals.

In considering how organic production in Wales can be consumed in Wales, the authors recognise the fact that changing supply chains is not a speedy process. Ultimately a complete production – consumption supply network would be established. However this will take time, suggesting that current major supply chain routes should be used. Two major procurement chains that could be explored is the NHS and schools. Both are large purchasers of food and potentially purchase a considerable proportion from the Welch organic market. For the NHS a considerable amount of food is purchased centrally through NHS PASA. Even though NHS PASA has to adhere to European Procurement Law, defining in tenders that the food should have a low environmental impact would favour locally produced organic food.

A recent study of the NHS demonstrated that over 53,256 tonnes were purchased in 2001. It is estimated that 4,000 tonnes is consumed in Welsh hospitals. Accepting the national breakdown of food consumed by the NHS allows a comparison between the potential supply of organic food in Wales and the possible demand by the NHS in Wales. The analysis suggesting that, apart from a few products, capacity is already available.

In conclusion, Welsh production volumes of organic food would be sufficient to cover the demand if all food in the NHS were to be organic and local.

3.4 Conclusions

The advantages of organic farming in nearly all agricultural policy areas, the current level of demand, and the current policy opportunities, means that organic production should now be taken up as a mainstream policy option for Welsh agriculture. However an increase in organic food production and consumption is not enough. Increasing the proportion of organic agriculture doesn't bring about a substantial reduction in the Ecological Footprint. This is an indication that it's not just about the quality of the food we eat but also what types of food our diet is composed of. This is where the nutrition strategy nicely complements the organic strategy, highlighting the need for complementing strategies.

To increase the procurement of organic food products in Wales it is realised that there needs to be a reliance on existing supply chains. It is suggested that significant headway could be made in the levels of organic consumption if hospitals and schools considered the option of increasing levels of organic food procurement in their healthy eating strategies.

The analysis of food eaten by school children demonstrates the importance of diets in reducing the Ecological Footprint and improving health.

4. Energy

4.1 Energy Consumption

Energy is a fundamental component of everyday life, but the current energy system is disrupting the global climate. This is possibly the greatest single threat to the global environment, a problem for which every nation and every region has to accept some responsibility. The Ecological Footprint approach has much to offer to this agenda:

- It provides a common platform for comparing energy and infrastructure to other sectors.
- It provides a direct assessment of the impact of different energy futures and energy strategies on the global environment. The wider scope of a regional energy-climate strategy can only be sketched here.
- It includes 'supply-side' actions on energy fuels and markets as well as 'demand-side' actions on housing, transport and production.

In this chapter a look is taken at the overall energy consumption within Wales and its composition. Welsh energy policy is overviewed and targets are analysed. Projections are then made to determine the reduction achieved in the Ecological Footprint by reaching these targets.

4.1.1 DOMESTIC ENERGY CONSUMPTION IN THE UK

Direct energy is consumed at the household level in the form of electricity, gas, coal, wood and fuel oil[25]. In the UK, there has been a significant shift from solid fuel to natural gas over the past 30 years (Figure 11)[26].

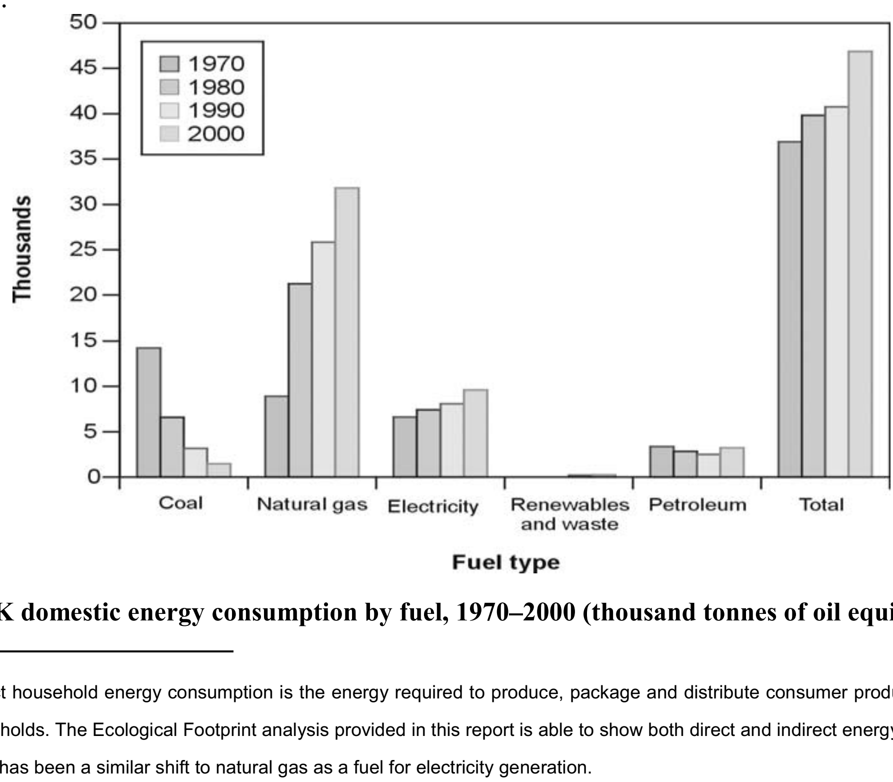

Figure 11: UK domestic energy consumption by fuel, 1970–2000 (thousand tonnes of oil equivalent)

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25 Indirect household energy consumption is the energy required to produce, package and distribute consumer products and to provide services for households. The Ecological Footprint analysis provided in this report is able to show both direct and indirect energy footprints.

26 There has been a similar shift to natural gas as a fuel for electricity generation.

Domestic energy consumption increased by 32 per cent between 1970 and 2000, despite energy efficiency improvements such as increased levels of insulation and more efficient electrical appliances[27], and now accounts for almost a third of UK energy consumption. Factors that have contributed to this trend include increases in disposable income, in the number of domestic properties and the use of electrical appliances. Over half of the energy consumed in homes is for space heating, 18 per cent is for cooking, lighting and appliances and the remainder (24 per cent) is for heating water (Figure 12 and Figure 13).

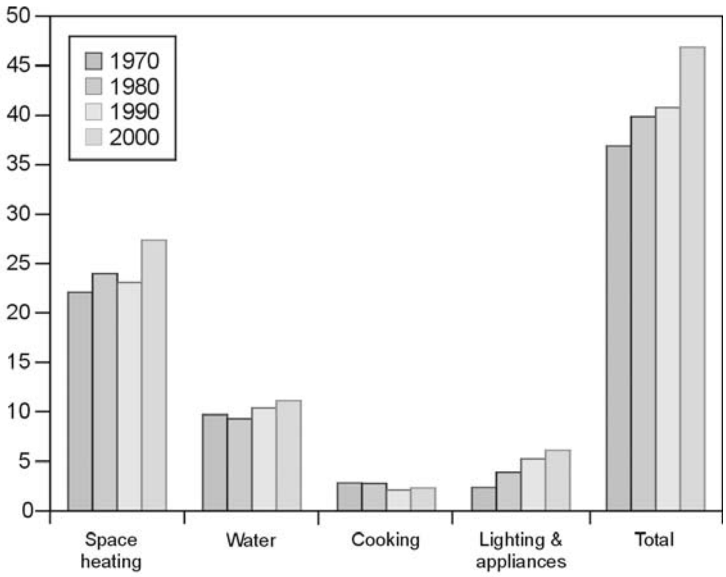

Figure12: Domestic energy consumption by end use, 1970-2000 (million tonnes of oil equivalent)

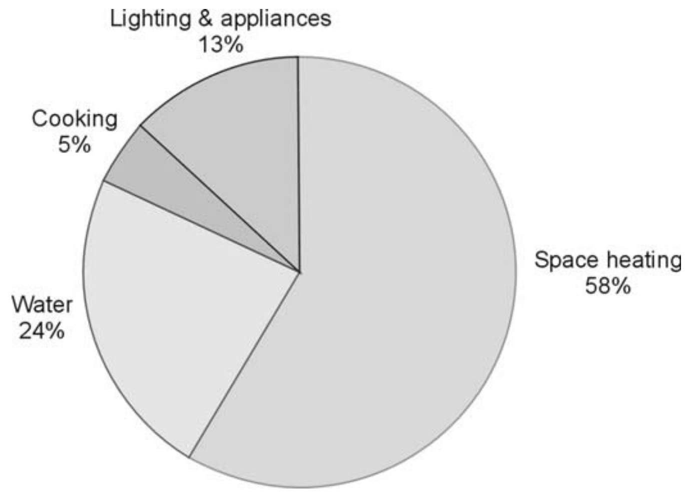

Figure 13: Domestic energy consumption by end use, 2000

27 For UK domestic heating in 2000, the energy savings resulting from insulation (15.7 million tonnes of oil equivalent) and improved efficiency of heating systems (12.9 million tonnes of oil equivalent) in effect halved the energy consumption of space heating (at 26.5 million tonnes of oil equivalent) *Energy consumption in the UK, 2002.*

Although household appliances only account for about a tenth of direct energy consumption, the energy consumed during their manufacture and distribution is significant (see chapter 9 on the consumption of consumables and durables). The resources required during the production of these items, and their disposal in landfill sites, have become topical issues.

4.1.2 DOMESTIC ENERGY CONSUMPTION IN WALES

For the UK as a whole, it is forecast that annual demand for gas will grow by 35 per cent over the next 10 years. Above average growth in demand for gas is predicted in Wales due to more spare potential for switching to gas especially through local Combined Heat and Power (CHP) schemes. Medium-sized (~500MW) Combined Cycle Gas Turbines (CCGTs) power plants are in development at Baglan Bay and on Anglesey and one is proposed for Pembrokeshire. A large-sized (1400MW) CCGT is proposed for Rassau near Ebbw Vale (SEL, 2000).

4.2 Results Summary

In this study, all energy consumed within Wales has been accounted for. The direct energy use by households has been calculated using the methodology detailed in chapter 2. This includes the analysis of the consumption of gas, electricity and other fuels. The CO_2 emissions and Ecological Footprints have been calculated for domestic lighting, cooking, heating, hot water and other electrical equipment power consumption by the residents of Wales. The impact of energy used in the commercial and service sector has been assigned to each individual service or commercial entity using the input-output table (see the appendix for a full description). However the flexibility of the methodology has allowed for the data to be extracted and also presented within this chapter. Transport energy is considered separately in chapter 6, as is the energy used during the production of goods consumed in Wales, termed 'embodied energy'.

4.2.1 DIRECT ENERGY CONSUMPTION

The direct domestic energy consumption in Wales has been calculated using the methodology as described in the appendix of this report. This used a combination of the input-output table results and direct data. From this information it is possible to attain a detailed picture of not only the total energy consumption of a typical Welsh resident for six major fuel types but to also gain an understanding of exactly how this fuel consumption is used. The results are shown below in Table 20 andTable 21.

Table 20: Energy Consumption and Carbon Dioxide emissions in the UK and Wales 2001

	Total Energy Consumption GWh		Energy Consumption kWh/cap/yr		CO_2 Emissions kg/cap/yr	
	UK	**Wales**	**UK**	**Wales**	**UK**	**Wales**
Electricity	123,281	6,868	2,097	2,366	837	1,017
Coal	13,110	598	223	206	69	62
Gas oil	1,764	81	30	28	7.7	6.9
Fuel oil	59	3	1	1	0.2	0.1
Natural gas	367,608	16,800	6,253	5,787	1,223	1,099
Solid biomass	2,352	107	40	37	0.8	0.7
Other	39,447	1,803	671	621	131	118
Total	**535,509**	**26,258**	**9,109**	**9,045**	**2,269**	**2,305**

In 2001 the residents of Wales consumed somewhere in the region of 26 billion kilowatt-hours (kWh) of energy. The major source of this energy was in the form on natural gas followed by electricity. The average Welsh resident consumes less energy than the average UK resident with a consumption of 9,045 kWh and 9,109 kWh per year respectively. Despite this, carbon dioxide emissions of energy consumption in Wales are higher than those for the UK. This higher impact arises as a consequence of the different mix of fuels consumed. In Table 20 above it can be clearly seen that in Wales the average resident consumed more electricity and less natural gas than the average UK resident. This results in a higher environmental impact as UK electricity is responsible for twice the amount of CO_2 emissions per unit of energy than natural gas[28].

Of the different fuels listed in Table 21, natural gas produces the second lowest emissions of CO_2 per kWh (the lowest being solid biomass). Over the past 10 years the use of natural gas in households and to generate electricity has increased substantially. The "dash for gas" was responsible for a considerable reduction in CO_2 emissions in the UK. Between 1990 and 1999, there was a 36 per cent reduction in CO_2 emissions per kWh (from 0.80 to 0.51 kg/kWh) as natural gas replaced coal as the main fuel at UK power stations. However, over more recent years, gas price increases have resulted in some power stations switching back to coal. Renewable energy generation could reduce the greenhouse gas emissions associated with the production of electricity and other energy needs significantly.

[28] DEFRA (2003) A Guide to Company Reporting of Greenhouse Gas Emissions (http://www.defra.gov.uk/environment/envrp/gas/index.htm.

Table 21: Breakdown of energy use within Welsh Households, 2001

Energy use kWh/cap/yr	Electricity	Coal	Gas oil	Fuel oil	Natural gas	Solid biomass	Other	Total
Space heating	175	206			2,140	37.1		2,558
Hot water	146				2,188			2,334
Cooking	584		27.7	0.5	1,459			2,071
Lights and appliances	1,461				-			1,461
TOTAL	**2,366**	**206**	**28**	**0.5**	**5,787**	**37**	**621**	**9,045**

4.2.2 MATERIAL FLOW ANALYSIS RESULTS

Table 22 shows the direct plus indirect flow of energy carriers for the UK and Wales, allocated to household and other consumption activities. It is important to bear in mind that this table includes indirect, i.e. embodied flows of materials. For example, the provision of food requires 124,000 tonnes of oil and gas in Wales because the food has to be processed, transported and packaged. It does not mean that this amount of oil and gas is actually consumed by households; it rather means that households are indirectly responsible for the flow of these energy carriers.

Table 22: Allocation of direct and embodied energy carrier flows (in kg/capita) to household and other consumption activities in the UK and Wales

COI-COP	Consumption category	Coal Consumption		Oil and Gas Consumption		Refined petroleum, etc.	
	Household consumption	UK	Wales	UK	Wales	UK	Wales
	Food						
1.1	Food	18.2	17.7	43.3	42.1	31.2	30.3
1.2	Non-alcoholic beverages	2.3	2.2	4.6	4.4	3.1	3.0
2.1	Alcoholic beverages	3.5	3.8	7.1	7.6	4.8	5.1
11.1	Catering services	30.7	28.7	157.8	147.6	72.4	67.8
	Energy						
	Domestic Energy Consumption	31.9	26.1	498.8	410.0	-	-
4.5	Electricity, gas and other fuels	351.1	353.4	516.9	520.3	36.3	36.5
	Transport						
	Private transport (car fuel)	-	-	-	-	584.3	556.8
7.1	Purchase of vehicles	15.2	10.7	40.1	28.3	17.3	12.2
7.2	Operation of personal transport equipment	12.3	11.7	205.7	196.0	249.2	237.5
7.3	Transport services	12.7	6.8	76.7	41.4	80.5	43.5
	Infrastructure						
4.1	Actual rentals for housing	3.8	2.6	12.6	8.5	8.2	5.6
4.2	Imputed rentals for housing	8.6	5.8	28.2	19.0	18.3	12.3
4.3	Maintenance and repair of the dwelling	6.8	5.7	16.7	13.9	14.1	11.8
	Consumables						
2.2	Tobacco	0.6	0.6	1.6	1.5	1.0	1.0
9.5	Newspapers, books and stationery	2.7	2.4	7.0	6.1	5.1	4.4
12.1	Personal care	3.0	2.5	7.7	6.3	5.4	4.4
	Durables						
3.1	Clothing	3.4	2.6	7.9	6.1	4.97	3.8
3.2	Footwear	1.3	1.1	4.3	3.8	3.4	3.0
5.1	Furniture, furnishings, carpets etc.	2.3	2.0	5.3	4.5	3.4	2.9
5.2	Household textiles	1.6	1.5	4.3	4.1	3.2	3.1
5.3	Household appliances	13.3	10.9	46.2	37.9	38.0	31.2
5.4	Glassware, tableware, etc.	1.2	0.8	3.2	2.0	1.4	0.9

COI-COP	Consumption category	Coal Consumption		Oil and Gas Consumption		Refined petroleum, etc.	
	Household consumption	**UK**	**Wales**	**UK**	**Wales**	**UK**	**Wales**
5.5	Tools and equipment for house and garden	1.1	1.2	3.7	4.0	3.0	3.3
5.6	Goods and services for HH maintenance	0.9	0.8	2.6	2.3	2.1	1.9
6.1	Medical products and equipment	1.1	0.9	4.1	3.2	3.7	2.9
8.2	Telephone and telefax equipment	0.07	0.03	0.2	0.07	0.1	0.07
9.1	Audio-visual and photo equipment	8.0	8.3	26.9	27.9	22.5	23.3
9.2	Other durables for recreation and culture	1.4	0.8	4.9	2.8	4.2	2.4
9.3	Other recreational items & equipment	3.8	4.0	10.6	11.3	7.0	7.4
12.3	Personal effects n.e.c.	13.1	8.5	45.6	29.6	37.5	24.3
	Water						
4.4	Water supply and misc. dwelling services	3.5	4.1	6.5	7.7	3.6	4.3
	Services						
6.2	Out-patient services	0.8	0.3	2.7	1.0	2.1	0.8
6.3	Hospital services	0.6	0.6	1.8	1.8	1.4	1.4
8.1	Postal Services	0.2	0.1	0.8	0.5	0.7	0.4
8.3	Telephone and telefax services	3.1	2.5	12.0	9.7	10.6	8.5
9.4	Recreational and cultural services	8.0	7.8	20.1	19.6	11.5	11.2
9.6	Package holidays						
10	Education	3.5	1.7	10.3	5.1	7.6	3.8
11.2	Accommodation services	4.9	3.7	25.5	18.9	11.7	8.6
12.4	Social protection	3.1	2.1	10.6	7.0	7.7	5.1
12.5	Insurance	7.1	5.7	28.7	23.1	25.4	20.5
12.6	Financial services n.e.c.	5.1	2.8	22.2	12.2	20.4	11.2
12.7	Other services n.e.c.	2.9	2.2	8.2	6.3	5.8	4.4
	UK resident holidays abroad	11.8	11.7	40.7	40.7	28.0	28.0
	Sub total household consumption	**612**	**571**	**1,987**	**1,748**	**1,404**	**1,253**
	Other final consumption	**UK**	**Wales**	**UK**	**Wales**	**UK**	**Wales**
	Other consumption (final demand)	-	-	-	-	-	-
	Gross fixed capital formation	77.7	77.6	224.8	224.5	126.2	126.1
	Non-profit inst. servicing households	6.9	6.9	19.6	19.5	13.7	13.6
	Central government	35.4	35.3	104.9	104.8	80.1	80.0
	Local government	24.0	24.0	70.1	70.1	52.5	52.4
	Valuables	0.02	0.00	0.18	0.17	0.2	0.2
	Changes in inventories	26.7	26.6	-12.3	-12.3	5.0	5.0
	Export of Goods	105.8	105.7	2,069.1	2,066.5	662.1	661.4
	Export of services	41.1	41.0	183.5	183.3	135.2	135.1
	Overseas tourists in the UK	-8.3	-8.3	-30.0	-30.0	-15.6	-15.6
	Sub total other final consumption	**310**	**309**	**2,630**	**2,627**	**1,060**	**1,058**
	Total flow of energy carriers	**922**	**880**	**4,617**	**4,375**	**2,464**	**2,311**

4.2.3 ECOLOGICAL FOOTPRINT RESULTS

Table 23 shows the energy footprint of Wales and the CO_2 emissions that can be attributed to the various consumption activities (for a detailed discussion on CO_2 emissions please refer to Chapter 2 of this report (Overall Results)).

Table 23: Energy Footprint and associated carbon dioxide emissions (consumer principle) of household and other consumption activities in Wales

	Energy Footprint gha/cap/year	CO_2 Emissions t/cap/year
Food and Drink a)	0.271	0.91
Energy	0.833	2.79
Travel b)	0.713	2.39
Housing	0.092	0.31
Consumables	0.355	1.28
Services	0.155	0.52
Holiday Activities	0.036	0.12
Capital Investment c)	0.560	1.87
Government d)	0.312	1.04
Other e)	0.024	0.08
Total	**3.34**	**11.3**

a) includes catering services
b) includes transport services and air travel
c) Capital Investment or Gross Fixed Capital Formation (GFCF). The Footprint calculations assume shared responsibility, i.e. equal values for UK and Wales.
d) Includes central and local government. Assumes shared responsibility, i.e. equal values for UK and Wales.
e) includes non-profit institutions serving households, valuables, changes in inventories and overseas tourists in the UK; the latter one leading to an overall negative Footprint.

When purely looking at direct energy consumption, the total Ecological Footprint for Wales is 2.7 million global hectares, or 0.916 gha per person. This equates to 17 per cent of the total footprint per person. This energy supply produces 6.7 million tonnes, or 2.3 tonnes of CO_2 per person per year.

Table 24: The Ecological Footprint and direct Carbon Dioxide emissions of Household energy consumption in Wales

Wales	Electricity	Coal	Gas oil	Fuel oil	Natural gas	Solid biomass	Other	Total
CO_2 emissions (kg/cap/yr)	1,017	62	6.9	0.1	1,099	0.7	118	**2,305**
Footprint (gha/cap/yr)	0.405	0.025	0.003	0.000	0.437	0.000	0.047	**0.916**

The major component (90%) of the Ecological Footprint of energy consumption comes from energy land. This is the ‘theoretical’ land needed to reabsorb the carbon dioxide emitted from the burning of different fuel types. The second biggest component of the Ecological Footprint breakdown is the built land component. This represents all the infrastructure needed to supply consumers with energy.

Table 25: The Ecological Footprint components of energy consumption in Wales (gha / capita / year)

	Wales	Energy	Crop	Pasture	Built Land	Sea	Forest
Domestic Energy Consumption	0.512	0.434	-	-	0.075	-	0.002
Electricity, gas and other fuels	0.405	0.399	0.001	0.000	0.001	0.001	0.002
Total EF	**0.916**	**0.833**	**0.001**	**0.000**	**0.076**	**0.001**	**0.005**

The table below shows the energy Footprint of services; more precisely the energy Footprint of household consumption activities that demand services from different economic sectors. It also shows the carbon dioxide emissions that are associated with these activities and for which the consumer is being held responsible.

The last three services in Table 26 are listed separately because they have been included in other components, namely catering services in food (Chapter 4) and transport services and aviation in transport (Chapter 6).

Table 26: Energy Footprint, total Footprint and CO_2 emissions of service consumption in Wales

COICOP	Consumption category	Energy Footprint	Total Footprint (incl. all land area types)	Carbon dioxide emissions (responsibility principle)
		gha/cap/yr	gha/cap/yr	t CO_2/cap/yr
04.4	Water supply & misc. dwelling serv.	0.019	0.021	0.071
06.2	Out-patient services	0.002	0.002	0.007
06.3	Hospital services	0.003	0.004	0.012
08.1	Postal Services	0.001	0.001	0.003
08.3	Telephone and telefax services	0.015	0.018	0.056
09.4	Recreational and cultural services	0.026	0.042	0.098
09.6	Package holidays		-	-
10.	Education	0.009	0.013	0.033
11.2	Accommodation services	0.015	0.053	0.058
12.4	Social protection	0.011	0.017	0.041
12.5	Insurance	0.028	0.037	0.107
12.6	Financial services n.e.c.	0.014	0.018	0.053
12.7	Other services n.e.c.	0.012	0.017	0.044
	Total for first 13 services	*0.155*	*0.243*	*0.58*
11.1	Catering services [a)]	0.120	0.411	0.45
07.3	Transport services, excl. aviation [b)]	0.057	0.066	0.21
	Aviation [b)]	0.198	0.198	0.74
	Total for all services	**0.530**	**0.918**	**1.99**

a) see also Chapter 4 (Food)
b) see also Chapter 6 (Transport)

The highest energy consumption – and hence the highest energy Footprint and CO_2 emissions – occur when people travel on aeroplanes. Aviation accounts for almost 0.2 gha per person and 740 kg of CO_2 emissions per year. Catering services, i.e. eating out, have the second highest energy Footprint (0.12 gha/cap) and the highest total Footprint (0.41 gha/cap) as the provision of food requires real land area as well. Other services have a substantially lower energy Footprint, of which other transport services (0.057 gha/cap), insurance (0.028 gha/cap) and recreational and cultural services (0.026 gha/cap) should be mentioned.

4.3 Policy Implications

4.3.1 WELSH POLICY CONTEXT

Climate change is now recognised as one of the greatest environmental, social and economic threats facing the planet[29]. In its Third Assessment Report, published in 2001, the IPPC projects that global average surface temperatures will rise by a further 1.4 to 5.8°C by the end of this century indicating that climate change may a bigger threat than first anticipated.

The United Nations Framework Convention on Climate Change presented at the Rio Earth Summit in 1992 symbolised the dawn of international recognition of unacceptable rising levels of greenhouse gases. By 1997 that recognition had evolved into action, in the form of the Kyoto Protocol, enabling developed countries to commit themselves to reducing their collective emissions of six key greenhouse gases by at least 5% from 1990 levels. The European Union has arranged to meet its' target by distributing different rates among its' member states, the UK included.

The UK's Climate Change Programme was published in November 2000. It details how the UK plans to deliver Kyoto targets to cut greenhouse gas emissions by 12.5%, and move towards its' domestic goal to cut carbon dioxide (CO_2) emissions by 20% below 1990 levels by 2010[1]. The Energy White Paper, published in 2003, sets out the longer term strategic framework for the UK's energy policy and accepted that the UK should put itself on a path to reducing CO_2 emissions by some 60% by 2050[30]. Although the development of these energy policies in the UK has been driven by the threat of climate change, dwindling indigenous energy supplies (i.e. oil, gas and coal) and the need to update existing energy infrastructure have also played a role.

Wales has a crucial role to play in the reduction of CO_2 emissions. To date, the Welsh Assembly Government (WAG) have not compiled or implemented an energy strategy specifically for Wales. They have however undertaken and funded a number of consultation documents[31] and studies[32], the findings of which form the basis of the Economic Development Minister's Energy Statement in 2003.

The passing of the Warm Homes and Energy Conservation Act 2000 provided an opportunity for WAG to consolidate their work in the field of fuel poverty. The Home Energy Efficiency Scheme then followed in November 2000 and the Fuel Poverty Commitment for Wales was presented in 2003.

4.3.2 KEY POLICY OBJECTIVES & TARGETS

Wales faces very particular challenges in seeking to reduce CO_2 emissions for two reasons: it is proportionally more dependant on heavy industry and electricity as a source of energy than other regions of the UK. Indeed, due mainly to increased emissions occurring in industry, CO_2 emissions in Wales rose between 1990 and 1995[4]. The projected increase in economic activity and prosperity in Wales, however, is likely to lead to an increase in energy consumption. To achieve a significant reduction in the greenhouse gas emissions caused by the supply and consumption of energy, the WAG have specified five policy priority areas with a vision of transforming Wales into a global showcase for sustainable clean energy production and energy efficiency (See Table 27).

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[29] Climate Change: The UK Programme (2000) DETR
[30] Energy White Paper: Our Energy Future – Creating a Low Carbon Economy (2003) Dti
[31] Review of Energy Policy in Wales: Part 1 Renewable Energy and Part 2 Energy Efficiency (2002) Economic Development Committee, National Assembly for Wales.
[32] Strategic Study of Renewable Energy Resources in Wales (2000) Sustainable Energy Limited, Dulas Limited, Newidiem and Ecotec Research and Consulting Limited.

Table 27: Energy policy priorities as set out by the WAG (2003)

Energy Policy Priority Areas
1. Pursuing now, much greater energy efficiency, including small-scale on-site CHP and renewables plants, in our domestic, business and public sectors, working in partnership with local authorities.
2. A strong drive in Wales now, against appropriate benchmarks, for a sustainable mix of renewable energy developments. Target: Supply 4TWh of renewable energy by 2010 and 7TWh by 2020.
3. Encouraging energy infrastructure improvements and pressing for reform of electricity trading arrangements.
4. Encouraging now, the production in Wales of electricity from new clean coal power stations.
5. The setting of achievable and measurable carbon dioxide reduction targets for 2020. Target: Reducing current carbon emissions by 20% or 2.5 mega tonnes of carbon by 2020.

The Warm Homes and Energy Conservation Act commits the WAG to setting interim objectives and targets for achieving these and a specific target date for achieving the objective that '…as far as reasonably practicable persons in Wales do not live in fuel poverty.'[33] See Table 28 for details.

Table 28: Targets set out in the Warm Homes and Energy Conservation Act 2000: A fuel poverty commitment for Wales (2003)

Targets
Overall Target Date:
• Eradicating fuel poverty amongst vulnerable households as far as is practicable by 2010. • Seek an end to fuel poverty amongst non-vulnerable households in social housing by 2012 and intend to work further in partnership with other interested groups in order that as far as reasonably practical no household in Wales should live in fuel poverty beyond 2018.
Interim Targets:
• Assisting 38,000 vulnerable households, mostly in the private sector, through the Home Energy Efficiency Scheme by March 2004. • Assisting a total of 95,000 homes, through the Home Energy Efficiency Scheme by March 2007.Using the proxy of HEES eligibility for Fuel Poverty this would represent a 43% reduction in fuel poverty. • Between September 2002 and the end of 2006 (at the latest), Local Authorities and RSL's must assess the condition of their stock, finalise and implement a programme for the repair and improvement of the stock. • The Assembly will commit to setting a target, within the overall requirements of the Act which does not exceed March 2018, for non vulnerable people (single persons and families without children) living in fuel poverty, once this information has been received from the Welsh Household and Dwelling Survey in 2004.

[33] Warm Homes and Energy Conservation Act 2000: A fuel poverty commitment for Wales (2003) WAG

The policy priority areas identified and targets set out to eradicate fuel poverty are quite distinct, however they reflect the needs of Wales while at the same time complimenting and underpinning the UK Energy White paper.

4.3.3 ECOLOGICAL FOOTPRINT IMPLICATION

At present 95 per cent of UK CO_2 emissions are from fossil fuel use[4], and domestic energy consumption accounts for a third of this total. Thus there is no doubt that increasing energy efficiency and renewable energy production, (thereby reducing the consumption of fossil fuel generated energy) will cut back CO_2 emissions and subsequently reduce the Ecological Footprint of energy. However, are the policies summarised in Table 27. sufficient enough to bring about the necessary change to meet the CO_2 reduction target for Wales and indeed Kyoto? The section which follows attempts to answer this question by generating a series of scenarios, taking into account future growths, projections and demands specific to Wales. The scenarios focus on three policy areas: firstly the development of renewable energy use and lastly the impact of improved energy efficiency in the home. The scenarios outline the effectiveness of the policies and the potential impact of the targets at reducing energy consumption and the Ecological Footprint of energy for Wales.

4.4 Future Scenarios

4.4.1 WHAT RENEWABLES ARE USED IN WALES?

Concerns about climate change, air pollution and energy security during the last decade have resulted in increased interest in renewable energy sources. The environmental benefits of a switch from coal, gas and nuclear energy sources to renewables include reduced emissions of direct greenhouse gas, other air pollutants and toxic substances. In the case of solar, wind and tidal projects, the environmental impacts of mining, refining and transporting fuel, as well as the risks associated with this (e.g. oil spills), are also avoided. The National Assembly for Wales (NafW) have highlighted other benefits associated with renewable energy, including:

- Wealth creation
- Creation of sustainable employment in Wales
- Regeneration
- Rural diversification
- Reducing CO_2 and therefore play a major role achieving the UK government target of 20% reduction by 2010
- Stimulating sustainable development in Wales

However, in the UK in 2000 renewable energy accounted for just over 1 per cent of energy production. Wales lies just above the national average at 1.3 % with 3% of its electricity production coming from renewables. Renewable energy sources include active solar heating, photovoltaics, onshore and offshore wind power, wave power, large and small-scale hydro, biofuels and geothermal aquifers. Although figures for energy recovery from waste combustion (e.g. tyres, hospital waste and refuse) are included as 'renewables' in certain reports, this process is by definition not renewable as a large proportion of domestic and industrial waste (and all waste tyres) consists of non-renewable material.

The report 'Strategic Study of Renewable Energy Resources in Wales' (SEL, 2000) contains a very detailed analysis of exactly what is going on in Wales with regards to renewables. In this report the present usage of each renewable is analysed, followed by a highly comprehensive report on the future potential for renewable energy in Wales. In this study some of the data from this report has been utilised for modelling purposes. Following this report the Welsh Assembly Government (WAG) has released a report entitled 'Facilitating Planning for Renewable Energy in Wales: Meeting the Targets' as an update to the TAN 8 (Technical Advice Note 8: Renewable Energy). This report detailed the most up to date information on renewable energy use in Wales and the likely changing consumption patterns over the next 15 years.

The following table shows the composition of renewable energy sources in Wales. It must be noted that although most data has been obtained from the aforementioned SEL report, some figures have been updated using more recent data published by The Welsh Assembly Government[34]:

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Table 29: Renewable energy usage in Wales (SEL, 2000)

Technology	Estimated present annual energy contribution			Estimated annual energy from projects in planning	
	GWh	GWh heat	percentage of total	GWh	GWh heat
Onshore wind energy	450*	-	48.1%	250*	-
Offshore wind energy	210*	-	22.5%	800*	-
Hydropower	210	-	22.5%	143	-
Biomass	-	1.9	0.2%	127	Up to 250
Biogas	1.9	-	0.2%	-	-
Active solar heating	-	1.5	0.2%	-	-
PV	0.1	-	0.0%	-	-
Tidal power	-			-	-
Wave power	-			-	-
Municipal waste	-			142	-
Landfill gas	119.8		12.8%	180	-
Mines gas	54.7		5.9%	13	-
Total	**931.5**	**3.4**	**100%**	**638.9**	**Up to 250**

*Up dated using the WAG renewables report (2004)

At present there are 365 turbines established in 19 wind farms within Wales, which provide almost 50% (450 GWh) of its renewable energy. This energy is used to produce electricity and makes up approximately 3.6% of all electricity consumed in Wales. At present there is the plan to build a further 76 onshore wind farms which it has been estimated would produce a further 2,786 GWh of energy per year, equating to 18% of all electricity consumed in Wales (SEL, 2000). Of these, planning consent has been given to four installations representing a further 72 turbines and bring the total capacity to around 0.7 TWh. The first off shore wind farm was constructed in 2003. It is the first commercial off shore wind farm in the whole of the UK and has 30 turbines generating some 0.2 TWh of energy a year. Recently permission for 2 more off shore wind farms has been granted and these three schemes together are predicted to provide over 1 TWh of energy[35]. Hydropower schemes have been generating electricity in Wales for a long time. The current schemes involve both small scale run off river schemes and larger storage schemes such as dams. There are no further plans for large scale hydro schemes due to the associated environmental impacts.

4.4.2 POTENTIAL OF RENEWABLE ENERGY USE IN WALES

The potential for renewable energy production by 2010 has been estimated in the 'Strategic Study of Renewable Energy Resources in Wales' produced by the Sustainable Energy Limited (SEL) and is presented below in Table 30.

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Table 30: Potential for renewable energy in Wales (SEL, 2000)

Technology	Full potential Annual energy contribution GWh	 GWh heat	Achievable potential Annual energy contribution GWh	 GWh heat
Onshore wind energy	121,000	-	3,000	-
Offshore wind energy	79,186	-	188 to 452	-
Hydropower	940	-	473 – 620	-
Biomass	9,145	Up to 18,290	1,301	Up to 2,603
Biogas	180	-	157	-
Active solar heating	-	665		33
PV	233	-	1	-
Tidal power	>>22,000	-	N/A	-
Wave power	3,000 to 6,000	-	N/A	-
Municipal Waste (*)	870	-	543	-
Landfill Gas (*)	361	-	361	-
Total	**>>236,000**	**Up to 18,955**	**6,024 to 6,435**	**Up to 2,636**

This table demonstrates that the estimated achievable potential of renewable energy in Wales by 2010 is between 6.4 – 9.0 TWh per year. It has been estimated that onshore wind farms offer the largest potential for renewable energy in Wales. For an explanation of the methodology and details on the assumptions please refer to the report on renewable energies[36]. Off shore wind generation comes in second highlighting the importance of wind farms in the future outlook for Welsh renewable energy.

This fits in well with the Welsh energy policy, which gives the following key recommendation with regards to renewable electricity generation:

'Wales should set itself a benchmark of 4TW per year. This is a realistic figure for 2010 on the basis of existing plans and amounts to just over 10% of Welsh electricity production'

The WAG suggest that this energy would be made up of equal parts of on shore wind, off shore wind and other renewable sources. It is also recognised that in the short to medium term, onshore and offshore wind are likely to be the most important factors enabling Wales to achieve its Carbon reduction targets, however in the longer term other such energy sources, such as tidal streams and biomass will likely play a larger role.

An analysis of this policy has been carried out by ARUP on behalf of the WAG[37]. It is suggested that the aforementioned '3 way split' of the 4TWh of energy is not the most likely breakdown of renewable energy consumption. They suggest a market driven model and base it upon estimates of likely developments of different technologies in current economic conditions. Their suggestions are displayed in Table 31 below.

[36] 'Strategic Study of Renewable Energy Resources in Wales' Sustainable Energies Limited (SEL) 2000
http://www.wales.gov.uk/subitradeindustry/content/consultations/renewableresources-e.htm

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Table 31: Estimated renewable energy consumption to reach the 4TWh Benchmark

Technology	"Market-driven" deployment of 4TWh 4000 GWh
Onshore wind	2,135 GWh
Offshore wind	945 GWh *
Other': Hydro & Biomass	920 GWh **

* assumes development of 3-4 offshore wind farms – a probable slight overestimate by 2010.
** assumes development of no further hydro but 50MW of biomass

Calculations have been made to determine the potential reduction in the Ecological Footprint that would be made if the target of 4 TWh by 2010 were to be achieved as well as the reduction if the total 'achievable potential' as estimated by SEL were to be met. Although in most calculations performed the carbon dioxide results are also displayed we have decided to omit them in this section due to their already very comprehensive coverage in the renewable energy report (SEL, 2000). The calculations comprise of two sections, the energy footprint (the theoretical land needed to absorb carbon dioxide emissions) and the real land footprint, i.e. the land needed for infrastructure.

The Energy Footprint

To determine the energy Ecological Footprint of each individual renewable energy source, data was obtained from a variety of sources. Firstly a study conducted by Stoglehner[38] detailed information on the energy land Ecological Footprint of different energy types. Factors were calculated by looking at the reduction in land area needed to provide energy via renewable energy sources in comparison to coal, fuels and natural gas and then applied to SEI's information on the Footprint of non-renewables. The calculated conversion factors are show in Table 32 below.

Table 32: The Energy Ecological Footprint of different fuel types

Fuel type	gha/GWh
Coal	119.28
Fuels	103.37
Natural gas	75.54
Elec. Photovoltaic	0.02
Elec. Wind	0.01
Elec. Water	0.07
Solar heating	0.01
Wood extensive	1.00
Wood intensive	0.51

The impacts of municipal waste incineration and energy derived from landfill gas were calculated separately.

Landfill gas is emitted at a landfill site due to the decomposition of organic matter. When matter decomposes it releases gas of which about 50% is methane, a powerful green house gas. Landfill gas should not be seen as a renewable energy option. In fact, burning landfill gas is actually dirtier than

[38] Stoglehner, G. (2003) 'Ecological Footprint – a tool for assessing sustainable energy supplies'. Journal of Cleaner Production 11 pp267-77.

burning natural gas; it emits more pollution per kWh than natural gas. For this reason the energy land Ecological Footprint conversion factor for natural gas was used to calculate the impact of landfill gas producing an **underestimate** of its impact.

When waste is burnt in an incinerator, heat is produced which can be used to generate electricity. Although some people class this method of energy generation as renewable it is not a renewable option. The alternative option, recycling, also uses energy, much of which is supplied by fossil fuels. However, if you look at the whole picture and take into account the entire life cycle of the material from its extraction to its disposal (the embodied energy) then it becomes apparent that incinerators are net energy looser rather than energy providers. In essence, they are destroying resources and turning them into toxic waste. The crucial factor that puts recycling ahead is that the extraction and processing of a material uses far less energy than the extraction and processing of virgin materials. Recycling materials saves three to five times the amount of energy that incinerating these same materials would generate.

To determine the energy land Ecological Footprint of incineration it was necessary to calculate the carbon dioxide emissions created via the incineration of landfill waste. The average carbon content of a tonne of waste was estimated to be 75 kg[39]. This results in the release of 275 kg of carbon dioxide on incineration (assuming that there is a 100% conversion rate). Table 33 shows that the achievable potential for energy generation from incineration is 543 GWh. Using the assumptions that one tonne of waste has a calorific value of 10GJ/tonne and that there is an efficiency of 25% it is estimated that you would need a total of 782 ktpa of waste to generate this electricity. This would release a total of 215,028 tonnes of $C0_2$ and produce a footprint of 54,654 gha.

Table 33: The energy Ecological Footprint of different renewable energy sources

	Benchmark of 4TWh by 2010	Energy EF	Achievable potential	Energy EF
	GWh	gha	GWh	gha
Onshore wind energy	2,135	17.1	3,000	24.0
Offshore wind energy	945	7.6	452	3.6
Hydropower	920	67.0	620	45.1
Biomass	-	-	3,904	3,892.8
Biogas	-	-	157	229.5
Active solar heating	-	-	33	0.2
PV	-	-	1	0.0
Tidal power	-	-	0	-
Wave power	-	-	0	-
Municipal Waste (*)	-	-	543	54,654.1
Landfill Gas (*)	-	-	361	27,270.7
Total	**4,000**	**91.6**	**9,071**	**86,120.1**

*Not true renewable energy sources

[39] National Atmospheric Emissions Inventory (NAEI)
http://www.aeat.com/netcen/airqual/naei/annreport/annrep97/app12_11.html

The Land Footprint

Data was also collected on the direct land area needed for different energy sources. The figures are shown in Table 34 below. It was assumed that hydro, wave and tidal electricity do not require any land area because they make use of already existing water systems. The land area for municipal waste incineration was assumed to be equal to the surface area of landfill sites in Wales. This was estimated to be approximately 1,475 hectares (the total for the UK being 28,000 hectares and Wales producing 5% of waste). The real land area for landfill gas is ignored as this will have been accounted for in the area needed for municipal waste incineration and hence avoids double counting. Biomass and biogas have the biggest real land requirement as you need direct land area to grow the crops. Wind energy has a fairly large real land component however the land can often have a dual use, such as for the farming of sheep, or may be land that cannot be used for any other purpose.

Table 34: Direct land use Ecological Footprint of renewable energise

	Land area per unit of energy	Achievable potential (SEL, 2000)	Land EF for achievable potential	Benchmark of 4 TWh by 2010	Land EF for Benchmark of 4TWh
	m^2/GWh	GWh	gha	GWh	gha
Onshore wind energy	100,000	3,000	30,000	2135	21,350
Offshore wind energy	100,000	452	4,520	945	9,450
Hydropower	0	620	0	920	0
Biomass	500,000	3,904	195,200	-	-
Biogas	500,000	157	7,850	-	-
Active solar heating	15,000	33	49.5	-	-
PV	15,000	1	1.5	-	-
Tidal power	0	0	0	-	-
Wave power	0	0	0	-	-
Municipal Waste*	-	543	1,475	-	-
Landfill Gas*	-	361	0	-	-
Total		**9,071**	**239,096**	**4,000**	**30,800**

*Not true renewable energy sources

Results

The Ecological Footprint of producing the 9,071GWh of energy detailed above using renewable resources totals 325,216gha (see Table 35). The biggest impact, of almost 200,000 gha, comes from energy generated from biomass. Although it produces over 60% of the total footprint the energy is only responsible for 43% of the total 9,071 GWh. The stark differences in impact between different energy sources can be clearly seen if you look at the differences between onshore wind energy and municipal waste incineration. With wind power it has been estimated that it is possible to achieve 3,000 GWh, or 33% of the total energy from renewable resources, yet it is only responsible for 9% of the impact. In contrast, energy generated from municipal waste is responsible for only 6% of the total energy generation and creates 17 % of the impact. This clearly demonstrates how the different options vary considerably in their environmental benefits.

Table 35: The total Ecological Footprint of different renewable energies

	Achievable potential GWh	Total EF gha	Benchmark of 4 TWh by2010 GWh	Total EF gha	EF per GWh gha/GWh
Onshore wind energy	3,000	30,024	2,135	21,367.1	10
Offshore wind energy	452	4,523	945	9,457.6	10
Hydropower	620	45	920	67.0	0
Biomass	3,904	199,092	-	-	51
Biogas	157	8,079	-	-	51
Active solar heating	33	49.7	-	-	2
PV	1	1.5	-	-	2
Tidal power	0	-	-	-	-
Wave power	0	-	-	-	-
Municipal Waste *	543	56,129	-	-	103
Landfill Gas *	361	27,270	-	-	76
Total / Average	**9,071**	**325,216**	**4,000**	**30,892**	**36**

*Not true renewable energy sources

Another good way to assess the results is to look at the impact via Ecological Footprint per Giga Watt-hour. In the above table it is very clear the incineration of municipal waste has by far the largest impact per unit of energy generation. It has double the impact of energy generated from biomass, ten times that generated from wind farms and fifty times the impact of energy from solar power. However as Table 36 demonstrates it is still below the impact of standard electricity generation which rates at 171 hectares per Giga Watt-hour.

To achieve the benchmark of 4TWh of energy derived from renewable resources by 2010 using the proposed energy mix as suggested by ARUP[40] it would take a total of just over 30,000 hectares. As can be seen in the above table the impact of wind energy per GWh is one of the lowest of all the renewable energy sources. For this reason the focus Wales has placed on producing energy in this manner will move Wales in the right direction to making significant reductions in its energy Ecological Footprint (for more details please see below).

Table 36 calculates the impact of the 9,071 and 4,000 GWh of energy if it was to be generated by electricity and Gas (the two major energy sources in Wales) i.e. how it is generated at present. The calculations have used a breakdown of 29% and 71% composition of electricity and gas respectively, which matches the present pattern of consumption in Wales.

For the ‘achievable potential’ renewable energy scenario, under normal circumstances it would require a total of 936,464 hectares to generate this energy. Hence, through the use of the renewable sources stated above it would be possible to make a saving of over 600,000 hectares. This value equates to 0.21 gha per capita which is a significant reduction. When compared to the total energy footprint in Wales, 0.916, this use of renewable energy could produce a 23% reduction in the Ecological Footprint of this component.

As can be seen in the table below, for the bench figure of 4TWh of energy, using a mix of electricity and gas it would require a total Ecological Footprint of 414,200 hectares. This can be compared to the

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suggested 30,892 required to generate this energy using renewable resources, making a total saving of 383,371 hectares. This equates to an average reduction of 0.13 hectares per Welsh resident or a 14% reduction. As can be seen, if Wales manage to reach this target and then go on to reach the 7 TWh target in 2020 they will have very made significant progress in reducing their environmental impact in the energy sector.

Table 36: The Footprint of energy consumption if renewables were not used

	Electricity	Gas	Total
Average in Wales	29%	71%	**100%**
EF per GWh	171	76	**-**
'Achievable potential' (GWh)	2,633	6,438	**9,071**
EF (gha)	450,103	486,360	**936,464**
4TWh Benchmark (GWh)	1,160	2,840	**4,000**
EF (gha)	198,360	215,840	**414,200**

If, however, renewables were to replace only electricity then there would be an even bigger reduction in the footprint due to the higher footprint per unit of electricity. To produce 9,071 GWh of energy with electricity alone it would create an Ecological Footprint of over 1.5 million hectares. By replacing this with renewable energy you could cut the footprint almost in half from 0.916 gha per resident per year down to 0.49 gha per year.

The same applies to if you were to replace 4TWh of electricity with renewable energy. Using solely electricity it required 684,000 hectares to produce this amount of electricity whereas with renewable it takes only 5% of this and hence the total Ecological Footprint for the energy sector would be reduced by 0.22 gha per Welsh resident bring the total Ecological Footprint down from 0.916 gha to 0.69 gha, a 25% reduction.

Conclusions

Through the use of renewable energy it is possible to reduce the Ecological Footprint of domestic energy use by an absolute total of 46 per cent if all potential sources of renewable energy were implemented to their maximum levels. If the WAG target of 4TWh of energy from renewables is achieved by 2010 it is possible to make a 25 per cent reduction in the Ecological Footprint of the energy sector. It must however be remembered that although renewables is one solution there are other options. At present domestic energy consumption is increasing year on year. One simple method to try and curb energy use is to encourage the public to use less energy. Simple measures such as turning down the heating a few degrees, turning appliances off after use and remembering to turn off the lights can reduce the impact of domestic energy consumption and such educative schemes should be worked on in parallel to renewable energy schemes to bring the reduction in energy consumption down even further.

A recent study titled 'Climate Concern: Attitudes to climate change and wind farms in Wales' (2004[41]) highlights the very important issue of attitudes and behaviours, and how these impact on the potential role of renewable energy, particularly wind farms. The survey findings showed that more people are in favour of onshore and offshore wind farms than are opposed to them – but 40 per cent were undecided. The findings of the study also demonstrated that knowledge of a problem does not automatically translate into action. The proportion of people who said that they were concerned about

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[41] 'Climate Concern: Attitudes to climate change and wind farms in Wales' (2004) Welsh Consumer Council and Friends of the Earth

climate change was substantially greater than the proportion who would have been doing something about it. Such issues would undoubtedly have repercussions for future development plans of wind farms across Wales.

The results also highlighted the high impact per GWh of landfill gas and waste incineration. The best option is to focus on the management of biodegradable waste through composting and recycling schemes rather than through incineration. For more information on such schemes in Wales please refer to chapter 8. When landfill gas or waste are used to generate energy it releases carbon dioxide (the energy portion of the Ecological Footprint), however the process of incineration releases a whole plethora of hazardous chemicals into the atmosphere as well as CO_2, most of which not only also cause global warming and other such environmental impacts but also release particular matter that cause health impacts. For these reason it is suggested that renewable energy policy takes a focus away from these energy sources and that biodegradable waste is managed through recycling and composting schemes.

4.4.3 WALES HOME ENERGY EFFICIENCY SCHEME

Wales is committed to the UK Fuel Poverty Strategy target of eradicating fuel poverty amongst vulnerable household as far as possible by 2010. It was decided to calculate the potential environmental savings that this type of scheme could generate.

The Home Energy Efficiency Scheme (HEES), set up by the Welsh Assembly has set a target for assisting:

- 38,000 homes by 2004
- 95,000 by March 2007.

In 2003 a report was released stating the progress so far per local authority. It appears that by this time somewhere in the region of 14,500 houses had benefited from the project. Activities had included the insertion of cavity walls, draught proofing, adding jackets to hot water tanks, loft insulation and the insertion of Compact Fluorescent Lighting (CFL). All the aforementioned activities not only help eradicate fuel poverty but also help in the achievement of a reduction in Carbon Dioxide emissions, and hence also reduces the Ecological Footprint.

Table 37 shows the activities that have taken place since the beginning of the project. The most common energy saving activity has been the insertion of Compact Florescent Lighting, with 95% of all properties having this energy saving measure carried out.

Table 37: Progress in the Welsh Home Energy Efficiency Scheme

	Total Properties	Cavity wall	CFL's	Draught, proofing	Hot water Tank Jacket	Loft insulation
	No of Properties	No of Properties	No of Properties	No of Properties	No of Properties	No of Properties
Isle of Anglesey	821	169	634	163	86	274
Blaenau Gwent	301	67	288	66	38	126
Bridgend	710	254	694	182	149	250
Caerphilly	957	255	938	302	113	397
Cardiff	1,400	410	1,326	501	161	342
Carmarthenshire	412	126	398	115	78	200
Ceredigion	372	127	361	101	76	141
Conwy	522	145	507	176	44	172
Denbighshire	429	162	408	192	57	192
Flintshire	553	210	529	231	100	204
Gwynedd	583	117	558	175	64	180
Merthyr Tydfil	743	358	736	160	85	216
Monmouthshire	175	61	166	33	23	85
Neath Port Talbot	657	256	628	209	127	272
Newport	511	228	490	147	85	233
Pembrokeshire	589	118	569	106	37	105
Powys	398	185	363	178	76	154
Rhondda Cynon Taf	1,227	227	1,200	410	256	517
Swansea	1,499	807	1,378	675	320	491
The Vale of Glamorgan	595	346	577	386	114	165
Torfaen	545	284	541	229	129	315
Wrexham	467	90	441	145	70	110
TOTAL	**14,466**	**5,002**	**13,730**	**4,882**	**2,288**	**5,141**

From the information provided it is unclear how many properties have had only one activity carried out and how many have had two or more. It is import to know this information when conducting energy saving calculations as each energy saving process has a knock on effect on the others. As it was not possible to obtain this information the calculations here are the maximum possible savings and most likely the real savings will be lower.

Average household energy use

Table 38 shows the average carbon dioxide emissions from a household broken down into a variety of energy consuming activities. As can be seen, the energy used for household heating is by far the largest component of household energy consumption, making up 60% of the total.

Table 38: Carbon dioxide emissions and footprint for a house by type of activity in the UK and Wales

	CO_2 Emissions TCO_2/**HH**/yr in UK	**Breakdown** %	**CO_2 Emissions** TCO_2/**cap**/yr in Wales	**Ecological Footprint** Gha/cap/yr in Wales
Heating	3.33	61%	1.41	0.56
Hot water	0.56	10%	0.23	0.09
Cooking	0.24	4%	0.09	0.04
Lighting	0.54	10%	0.23	0.09
Appliances	0.80	15%	0.35	0.14
TOTAL	**5.48**	**100%**	**2.31**	**0.916**

This household data was applied to welsh data on the average carbon dioxide emissions of a typical welsh resident. Using this data as a starting point it is possible to determine the energy saving reductions and associated carbon dioxide emissions of the different energy saving options being carried out in the Welsh Home Energy Efficiency Scheme (detailed above in Table 38) using data from the energy saving trust.

The potential savings of different energy saving options, such as loft insulation or cavity wall insulation, will create different reductions in energy consumption depending on the building type. These figures are shown below in Table 39. In Wales the percentage make up of house types is 34%, 32%, 28% and 6% for semi-detached, terrace, detached and flats respectively. From this data the carbon dioxide reductions through implementation of the home energy saving scheme of the average house in Wales has been calculated. The results are shown in the table below.

Table 39: Carbon dioxide emission savings per household type for different energy saving options

	Flat tCO_2/yr	**Terrace** tCO_2/yr	**Semi Detached** tCO_2/yr	**Detached** tCO_2/yr	**Average Welsh** tCO_2/yr	**Average Welsh** EF gha/cap/yr
Cavity wall	0.328	0.397	0.494	0.583	0.478	0.190
CFL's	0.152	0.152	0.152	0.152	0.152	0.060
Draught proofing	0.124	0.134	0.095	0.078	0.104	0.041
Hot water Tank Jacket	0.198	0.159	0.108	0.083	0.123	0.049
Loft insulation	0.229	0.918	0.085	0.075	0.357	0.142

If a house in Wales was to have none of the above energy saving measures, then through the Welsh Home Energy Efficiency Scheme it would be possible to make a saving of 1.2 tonnes of Carbon Dioxide, this equates to a 22 per cent reduction. It has been estimated that there is the potential to reduce the footprint by a maximum of 0.48 gha if all the above energy saving mechanisms were implemented into a house that was lacking them all.

From this data the total potential saving that has been made from Wales Home Energy Efficiency Scheme (HEES) can be calculated. The results are shown in Table 40. This has been calculated by multiplying the CO_2 reduction per energy saving option with the data detailed in Table 39 on the number of houses that have been part of the Welsh HEES. A summary table is shown below and more detailed results shown in Table 41.

Table 40: Carbon dioxide emission savings made from the HEES in Wales

	Total Properties	Cavity wall	CFL's	Draught proofing	Hot water Tank Jacket	Loft insulation
Number of Households	14,466	5,002	13,730	4,882	2,288	5,141
Saving tCO_2 / yr	7,103	2,390	2,086	509	281	1,837
EF saving **Gha/yr**	2,822.7	949.8	829.0	202.3	111.7	730.0

In Wales the domestic sector releases a total of 4.4 million tonnes of Carbon Dioxide in a year (Welsh National Assembly). With some 1.3 million households this averages out at approximately 3.4 tonnes per house per year. Using this information it has been possible to estimate the emissions from each local authority and hence the percentage reduction made through the HEES. The results are detailed below.

Table 41: CO_2 reductions from the HEES in Wales

	Total number of households	Estimated domestic emissions	Total Properties in HEES	Percentage of HH with work carried out	LA Saving	Percentage reduction
	No of Properties	CO_2 / yr	No of Properties	%	CO_2 / yr	%
Isle of Anglesey	31,782	109,081	821	2.6%	303	0.3%
Blaenau Gwent	32,063	110,045	301	0.9%	132	0.1%
Bridgend	57,831	198,485	710	1.2%	353	0.2%
Caerphilly	72,351	248,320	957	1.3%	452	0.2%
Cardiff	129,077	443,013	1,400	1.1%	592	0.1%
Carmarthenshire	75,784	260,103	412	0.5%	214	0.1%
Ceredigion	31,089	106,702	372	1.2%	186	0.2%
Conwy	52,330	179,605	522	1.0%	232	0.1%
Denbighshire	39,496	135,557	429	1.1%	235	0.2%
Flintshire	61,694	211,744	553	0.9%	290	0.1%
Gwynedd	56,819	195,012	583	1.0%	231	0.1%
Merthyr Tydfil	25,202	86,497	743	2.9%	387	0.4%
Monmouthshire	36,319	124,653	175	0.5%	91	0.1%
Neath Port Talbot	66,585	228,530	657	1.0%	352	0.2%
Newport	59,203	203,194	511	0.9%	292	0.1%
Pembrokeshire	53,579	183,892	589	1.1%	196	0.1%
Powys	56,527	194,010	398	0.7%	226	0.1%
Rhondda Cynon Taf	103,562	355,441	1,227	1.2%	550	0.2%
Swansea	96,147	329,992	1,499	1.6%	880	0.3%
The Vale of Glamorgan	50,790	174,319	595	1.2%	366	0.2%
Torfaen	38,897	133,501	545	1.4%	370	0.3%
Wrexham	54,865	188,305	467	0.9%	173	0.1%
TOTAL	**1,281,992**	**4,400,000**	**14,466**	**1.1%**	**7,103**	**0.2%**

The reductions in CO_2 shown in the table above appear to be very low, however it must be noted that the table only represents the 14.5 thousand houses that had been part of the HEES with available data, and hence only 1.1 per cent of the housing stock in Wales. The potential saving that will be made if the 2007 target of reaching 95,000 homes in the HEES is met has been calculated. It was assumed that the proportion of households targeted in each local authority would remain constant.

Table 42: Total potential savings by 2007 from the HEES in Wales

	Total HH	Total Emissions	No of households in HEES	Emission Reduction	Percentage Reduction	Ecological Footprint reduction
	No. of households	tCO2 / yr	No. of households	tCO2 / yr	%	Gha/yr
Isle of Anglesey	31,782	109,081	5,392	1,987	1.8%	789.6
Blaenau Gwent	32,063	110,045	1,977	869	0.8%	345.3
Bridgend	57,831	198,485	4,663	2,321	1.2%	922.4
Caerphilly	72,351	248,320	6,285	2,966	1.2%	1,178.7
Cardiff	129,077	443,013	9,194	3,885	0.9%	1,543.9
Carmarthenshire	75,784	260,103	2,706	1,403	0.5%	557.5
Ceredigion	31,089	106,702	2,443	1,220	1.1%	484.8
Conwy	52,330	179,605	3,428	1,520	0.8%	604.0
Denbighshire	39,496	135,557	2,817	1,543	1.1%	613.2
Flintshire	61,694	211,744	3,632	1,904	0.9%	756.6
Gwynedd	56,819	195,012	3,829	1,518	0.8%	603.2
Merthyr Tydfil	25,202	86,497	4,879	2,543	2.9%	1,010.6
Monmouthshire	36,319	124,653	1,149	598	0.5%	237.6
Neath Port Talbot	66,585	228,530	4,315	2,314	1.0%	919.6
Newport	59,203	203,194	3,356	1,920	0.9%	763.0
Pembrokeshire	53,579	183,892	3,868	1,287	0.7%	511.4
Powys	56,527	194,010	2,614	1,487	0.8%	590.9
Rhondda Cynon Taf	103,562	355,441	8,058	3,610	1.0%	1,434.6
Swansea	96,147	329,992	9,844	5,780	1.8%	2,297.0
The Vale of Glamorgan	50,790	174,319	3,907	2,405	1.4%	955.7
Torfaen	38,897	133,501	3,579	2,431	1.8%	966.1
Wrexham	54,865	188,305	3,067	1,136	0.6%	451.4
TOTAL	**1,281,992**	**4,400,000**	**95,000**	**46,648**	**1.1%**	18,537.8

Although the savings made from the HEES may at first appear small, it is important to bear in mind that the Ecological Footprint (and hence this report) cannot measure all aspects of sustainability. The HEES will be not only benefiting the environment but also improving social sustainability by allowing people access to a warm house.

Data from the Welsh House condition Survey (Chapter 3)[42] details the number of houses in Wales that have a range of energy saving devices within the home. These include insulation, draftproofing and double glazing and are detailed Table 43. From this table it is possible to estimate the greatest potential savings if all houses that lack such energy saving mechanisms were to be worked on.

Table 43: Home Improvements from the HEES in Wales

	% houses with…	Number of houses that could be worked on:	Energy Saving	Footprint Reduction
	%	No of houses	tCO_2 / yr	Gha/cap/yr
Roof/loft insulated	81	243,578	87,049	34,592
Cavity wall insulated	26.6	940,982	449,666	178,690
Windows double glazed	67.5	416,647	150,502	59,807
Door and windows draft stripped	53.2	599,972	62,551	24,857
Hot water tank insulated	89.3	137,173	16,851	6,696
Total		**2,338,352**	**766,619**	**304,641**

Table 43 shows that it would be possible to save an extra 766 thousand tonnes of CO_2 if the home energy efficiency measures were implemented across all houses in Wales lacking HEES improvements. This would reduce domestic emissions by 17 per cent and the Ecological Footprint by over 11%. However it must be admitted that this is a rather tall order as interventions like insulated cavity walls are rather expensive options. This data does however demonstrate the importance of implementing such measure when new buildings are being constructed.

Rebound effect

The rebound effect is the increase in consumption levels that often occurs when efficiency improvements reduce user costs. In the instance of energy consumption, an increase in home energy efficiency, such as a home insulation program that reduces heat losses by 50% will often not result in a full 50% reduction in energy consumption. This happens because once a home is insulated, the residents can afford to keep their homes warmer and hence some of the money saved is used to increase their levels of comfort and reinvested in turning the heating up a few degrees. This difference between the potential total saving of 50% and the actual saving is called the rebound effect. It has been estimated that the rebound effect associated with energy efficiency schemes is somewhere in the region of 10-40%[43]. However the actual size of the rebound can vary significantly and is dependant upon many variables such as the specific device and how developed the market and overall economy are. For example the rebound effect associated with the increased efficiency of home appliances has been calculated to be zero whereas the rebound effect for space heating can rise up to 50 per cent (See Table 44).

[42] http://www.wales.gov.uk/keypubstatisticsforwales/content/publication/housing/2001/whcs/three/whcs98tables3.pdf

[43] CRS Report for Congress. RS20981: Energy Efficiency and Rebound Effect: Does increasing Efficiency Decrease Demand? Frank Gottron. (2001)

Table 44: Measured rebound effect on various devices[44]

Device	Size of Rebound	Number of Studies
Space Heating	10-30%	26
Space Cooling	0-50%	9
Water Heating	10-40%	5
Residential Lighting	5-12%	4
Home Appliances	0%	2
Automobiles	10-30%	23

The consequence of this for Wales is that any savings that are predicted to come about through home energy efficiency schemes have to be treated with caution. The true savings are most likely not to be as high and could be up to 40% lower than predicted. Hence, when trying to accurately account the benefits of energy efficiency programmes, its important to also consider the rebound effect. However, on the other hand, it is also important to remember that losses in energy savings due to the rebound effect would generally be associated with gains in quality of life to the consumers.

4.5 Conclusions

As with many environmental concerns, a holistic approach is required to bring about a lasting reduction in CO_2 emissions. The scenarios demonstrated that renewable energy can be effective at reducing the Ecological Footprint. The scenario showed that the current target established by WAG would bring about a 25 per cent reduction in the Ecological Footprint. However, there is also the issue that energy demand is increasing, eroding the benefits of renewable energy in Wales making a marked difference in terms of CO_2 reduction.

The second scenario calculated the Ecological Footprint reduction by targeting energy consumption in households. Sadly, the scenario demonstrated that the energy efficiency schemes would do little to bring a about a reduction in the Ecological Footprint. The energy efficiency measures are simply not being installed in enough homes to make a difference. This does not mean that energy efficiency is not effective. If carried out on a large enough scale the reduction in CO_2 emissions would be substantial, even with the re-bound effect taken into account.

Therefore, the challenge for Wales is to ensure that the benefits of an ambitious renewable energy target are not lost through increasing demand for energy. Part of the increased demand is due to the large development of new houses in Wales. This issue is explored in more detail in Chapter 6. Briefly, if new housing developments were built to the standard of BedZed homes, they would require 90 per cent less energy than the average UK house. This would significant help to stabilise energy demand in Wales demonstrating that a holistic approach to energy policy could bring about substantial benefits.

[44] CRS Report for Congress. RS20981: Energy Efficiency and Rebound Effect: Does increasing Efficiency Decrease Demand? Frank Gottron. (2001)

5. Transport

5.1 Results

5.1.1 INTRODUCTION

Transport is vital to the economy and the way we live in Wales and over the last 35 years travel behaviour has evolved: not only in the way people travel, but also in the distances covered. On average Welsh residents travelled 9,835 kms in 2003, an increase of 6 per cent in the 10 years since 1992/1994; the average length of a journey has increased from 8.1 kms in 1975/1976 to 11 kms in 2003; and car travel now accounts for four fifths of the distance travelled[45].

Cars in particular have revolutionised the way we live, bringing greater flexibility and widening horizons. Between 1980 and 1997 there was a 65 per cent increase in motor vehicle traffic, almost all of which was increased car traffic, accounting for nearly 82 per cent of all road traffic in 1997[46]. Since then, traffic levels have grown by over 7 per cent - representing close to an extra 21 billion vehicle miles[47]. This rise in traffic volume has added to congestion, pollution and noise and has contributed to health problems including obesity and respiratory disease. This trend has been fuelled by Government policy focussing on accommodating increasing traffic and the car as the main mode of transport. Aviation has also become an important form of transport, both for international travel and for long distance journeys within the UK resulting in a five-fold increase in air travel over the last 30 years, with over half the population now flying at least once a year[48]. As with other forms of transport economic prosperity and the relatively low cost of private motorised transport have been the primary drivers of increasing demand. Advances in technology, competition and cost efficiencies have reinforced this trend. Alongside these developments, carbon dioxide emissions associated with transport have increased by 98 per cent between 1971 and 2001[49] and are currently estimated to produce a quarter of total UK emissions of carbon dioxide[2]. The European Commission's Public consultation on the review of the EU sustainable development strategy (SEC, 2004, 1042) has concluded:

"Energy efficiency per vehicle has improved substantially but this has been more than offset by the growth in the volume of transport, so that transport carbon dioxide emissions are rising, neutralising reductions achieved in other sectors" (page 19)

The Government's 10 year transport plan shows that on the road network overall, traffic levels are predicted to grow by 22 per cent between 2000 and 2010, with congestion in urban areas predicted to increase by 15 per cent, and inter-urban movements to grow by 28 per cent. On the rail network over the same period of time, the 10 year plan notes that a predicted growth in movements of 34 per cent would be limited to 23 per cent by constraints within the network (DTLR 1999).

As mentioned there has been a focus on increasing the supply of road space within a fiscal framework that continues to see the cost of motoring decline both in real terms and relative to the cost of public

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[45] National Travel Survey: 2003 Provisional Results (2004) Transport Statistics Bulletin, Department for Transport http://www.dft.gov.uk
[46] Transport Statistics Great Britain:2002 edition (2002) National Statistics Online
[47] Press Release: Traffic Levels Increase Again (2003) Friends of the Earth
[48] The Future of Transport: a network for 2030 (2004) Department for Transport
[49] Emissions of carbon dioxide: by end user (2004) Social Trends 34, National Statistics Online http://www.statistics.gov.uk

transport. This approach has been fundamentally flawed from some perspectives. It has encouraged a pattern of development that is car-orientated and characterised by ever-increasing trip length. There are many pressures and influences which have contributed to this, particularly the specialisation and out-sourcing of business, and the spatial concentration of commercial and public services.

5.1.2 MATERIAL FLOW ANALYSIS RESULTS

The most significant material flows related to the transportation system is the building of roads and other transport related infrastructure. These have both been included in Chapter 6, "Built Environment". Please refer to this chapter for the relevant information.

5.1.3 ECOLOGICAL FOOTPRINT RESULTS

The Ecological Footprint was calculated for passenger transport including air travel and the impact of Welsh residents while on holiday. Under the section of transport the following expenditure classifications were included:

- Car fuel
- Purchase of vehicles
- Transport services (sub divided into bus, train)
- Aviation
- Consumption while on holiday

The main findings were (see also Table 45):

- Personal transport makes up a noticeable proportion (15 per cent) of the total Ecological Footprint for Wales
- On a per capita basis, the Ecological Footprint of private transport is 0.50 gha/cap, clearly dominated by private car use (0.49 gha/cap).
- Aviation accounts for 0.26 gha/cap while for all forms of public transport the Ecological Footprint is 0.02 gha/cap.
- The total distance travelled on airplanes (6,600 km/yr Wales average) is considerably higher than the distance an average UK resident would fly (4,000 km/yr).
- According to the International Panel on Climate Change, the fact that a considerable proportion of aviation emissions are emitted in the upper troposphere and stratosphere, the impact in terms of global warming could be 2.9 times greater. This is the Global Warming Effect or GWE. Therefore, the associated Ecological Footprint of aviation could be as high as 0.75 gha/cap, one and a half times the impact of private transport on the road.
- Residents of Wales use the car less than the average person in the UK resulting in an Ecological Footprint that is 4 per cent lower for car fuel.
- Residents of Wales buy less cars than the average person in the UK. However, they spend more on maintenance meaning that the Ecological Footprint of these two activities is slightly higher for Wales than the UK (8 per cent).
- The average person in Wales travelled 16,524 km in 2001 of which 9,835 km (52%) were undertaken by car and 6,689 km (40%) by aeroplane. All other modes of transport – mainly public transport – accounted for only 8% of the total distance travelled.

Table 45 provides data on the average distance travelled by a Welsh resident in 2001 and its associated carbon dioxide emissions and Ecological Footprint.

Table 45: Average distances and total passenger-kilometres travelled by Wales residents in the year 2001 by different modes of transport.

Mode of transport	Average distance travelled per person [km]	Total passenger-kms by all Wales residents [billion (10^9) pkm]	CO2 Emissions (tonnes) per person	EF per 1000 km travelled (global hectares)	Total EF per person (global hectares)
Air travel - all services	6,689	19.43	0.63		0.255
... of which total international/EU	*6,590*	*19.14*	*0.610*	*0.038*	*0.249*
... of which total domestic	*99*	*0.29*	*0.020*	*0.061*	*0.006*
Walking (including short walks)	255	0.74	negligible		negligible
Bicycle	33	0.10	negligible		0.0001
Private hire bus	58	0.17	0.010	0.043	0.002
Car	8,673	25.18	1.47		0.489
... of which car driver	*5,542*	*16.09*	*0.940*	*0.088*	*0.313*
... of which car passenger	*3,131*	*9.09*	*0.530*	*0.044*	*0.177*
Motorcycle/moped	16	0.05	0.003	0.056	0.001
Van/lorry	115	0.33	0.020		0.009
... of which van driver	*81*	*0.24*	*0.015*	*0.078*	*0.006*
... of which van passenger	*34*	*0.10*	*0.005*	*0.078*	*0.003*
Other private (including invalid carriages, etc.)	14	0.04	0.002	0.059	0.001
Local bus	173	0.50	0.022	0.043	0.007
Non-local bus	87	0.25	0.006	0.022	0.002
Surface rail	323	0.94	0.022	0.022	0.007
Taxi/minicab	50	0.15	0.016	0.059	0.003
Other public (including ferries, light rail, etc.)	39	0.11	0.005	0.035	0.002
All modes excl. air travel	**9,835**	**28.6**	**1.580**	**-**	**0.52**
All modes incl. air travel	**16,524**	**48.0**	**2.21**	**-**	**0.78**

Source: UK Department for Transport, Transport Statistics, National Travel Survey 1999-2001 Update and Focus on Personal Travel 2001, 1999 from the UK within EU-15 including domestic flights (from:http://europ a.eu.int/comm/energy_transport/etif/transport_passenger_b/air_pkm.html)

5.2 Policy Implications

5.2.1 WELSH POLICY CONTEXT

In 2001 the WAG took the lead in transport policy for Wales and published 'The Transport Framework for Wales' with the aim to develop a better co-ordinated and sustainable transport system to support local communities and the creation of a prosperous economy. The main elements of the strategy are public transport, local authorities, ports, strategic infrastructure, safety, health and environment on our roads, freight, airports, walking and cycling.

A number of these elements have been explored in greater detail in separate reports and of particular interest to this study are the 'Trunk Road Forward Programme' (2002) and the consultation document for the 'Intra-Wales Scheduled Air Services' (2004).

The 1997 forecasts by the Department of the Environment, Transport and the Regions (DETR)[50] of the growth in volume of motor traffic (excluding motorcycles) indicate a central estimate of a 60 per cent increase between 1996 and 2031. Demand is also expected to continue growing in the aviation sector – to between two and three times current levels over the next 30 years[4]. The rest of this report will go on to examine how current transport policy in Wales proposes to cope with this demand in the context of ecological sustainability.

5.2.2 KEY POLICY OBJECTIVES & TARGETS

The road network represents a major component of the transport system in Wales. Trunk roads and motorways constitute about 5% of the length of roads in Wales but they carry over 50% of all traffic, and thus the majority of land-based movement of people and goods[51]. It is therefore considered vital to maintain and improve this service. The strategic priorities of the WAG for this task are laid out and reinforced in the 'Trunk Road Forward Programme' (2002), see Table 46 for details.

Table 46: Outline of the strategic and corridor objectives as presented in 'Trunk Road Forward Programme' (2002).

Strategic and Corridor Objectives – Trunk Roads from the Transport Framework for Wales
Over-arching objective:
To maintain and improve the trunk road network in Wales in a sustainable manner, taking into account the social, economic and environmental needs and obligations of the nation.
Network Objectives:
Accessibility:
To improve strategic (national and international) and regional accessibility and mobility. To reduce community severance. To meet the needs of disabled people. To give priority to the core network.

[50] DETR (1997) National Road Traffic Forecasts (Great Britain)

51 Trunk Road Forward Programme (2002) WAG

Safety:
To contribute towards safer communities including managing the speed of traffic to appropriate levels. To make a positive contribution to national road safety targets. To provide or encourage appropriately spaced stopping/resting places and facilities on the network. To improve personal security for travellers and others. To improve the detection, response and management of incidents on the trunk road network.
Environment:
Improve the quality of life for people in communities close to the trunk road network. To promote cycling and walking, and provide opportunities for healthy lifestyles. To minimise any adverse effects on the environment generally; to conserve and enhance, where appropriate, landscapes, townscapes and historic and cultural resources. To conserve and enhance, where appropriate, biodiversity on the network through the Biodiversity Action Plan.
Economy:
To bring up to standard and maintain the function of the trunk road network and to improve and maintain the trunk road asset. To preserve and enhance the operational efficiency of the trunk road network and help meet Wales' wider economic needs in a cost effective manner. To monitor and reduce journey time variability on the trunk road network.
Integration:
To facilitate improved interchanges between transport modes for people and freight. To take into account the needs for local and national planning and agriculture. To improve and develop travel and transport information systems.

The Programme is presented under four principal strategic corridors: North-South, East-West corridor in the South, East-West Corridor in the North, East-West Corridor in Mid-Wales. Timescale for delivery is covered in three phases: short-term (delivery before March 2005); medium-term (starting between 2005 and 2008) and long term (unlikely to start before 2008).

As stated in the consultation document ‘Intra-Wales Scheduled Air Services’ the WAG are keen to investigate the potential scope for scheduled air services within Wales in order to develop better transport links between the North and South as part of their integrated transport strategy. The analysis provides an overview of potential routes from a selection of possible airports along with estimates of the profits or losses, which would be achieved by an airline operator serving each network. The network options presented are highlighted in Table 47.

Table 47: Network options as presented in the 'Intra-Wales Scheduled Air Services' (2004) consultation document.

Option 1	**Round-Wales service (one aircraft operation):** Variant A — Cardiff, Withybush, Valley, Hawarden. Variant B — Cardiff, Withybush, Valley.
Option 2	**Cardiff hub:** Variant A — Cardiff, Withybush, Swansea, Valley, Hawarden (two aircraft operation). Variant B — Cardiff, Swansea, Valley (one aircraft operation).
Option 3	**Non-Cardiff route opportunities:** Variant A — Valley, Withybush, Swansea, Hawarden (two aircraft operation). Variant B — Valley, Withybush, Swansea (one aircraft operation).
Option 4	**Cardiff hub with Dublin:** Variant A (similar to Option 2B but includes Dublin) – Cardiff, Swansea, Valley, Dublin (one aircraft operation). Any service to Dublin would be a commercial matter for the airline operator.

The objective of developing air transport links between north and south Wales will have a significant effect on greenhouse gas emissions and the size of the Ecological Footprint. As a major strategic transport policy objective it should be investigated and justified with reference to alternatives within the Strategic Environmental Appraisal framework as required by EU law.

5.2.3 EF IMPLICATIONS

The overall aim of both 'Trunk Road Forward Programme' and 'Intra-Wales Scheduled Air Services' is to support and maintain a strong transport network throughout Wales by improving links, safety, access, journey times, physical severance, design schemes and integration with other modes of transport.

The approach suggested and being adopted may indeed bring about such benefits, however it is difficult to speculate accurately what impact it will have on travel behaviour. In addition, such improvements do not necessarily go hand in hand with a reduction of the Ecological Footprint. This issue is explored in the three scenarios, which have been developed in the section that follows. The first scenario is based on the actions being carried out to realise the improvements and maintenance of the road network across Wales. The second scenario forecasts on the potential impact of introducing a scheduled intra-air service on the Ecological Footprint. The analysis presented should give a good indication on whether the current plans to improve the road network and introduce an intra-air service across Wales will induce a positive impact on the current Ecological Footprint of transport in Wales.

The third scenario is about "Demand Management" and is vastly different from the other two. It is the only scenario that WAG has not considered in their policies. Moreover, it the only scenario that does not advocate an increase in infrastructure in Wales but concentrates on behavioural change and managing the demand for transport.

5.3 Future Scenarios

5.3.1 ROAD BUILDING IN WALES

A good indication of where priorities lie is to examine the financial backing given to the various modes of transport. While the necessary rhetoric exists to describe a “sustainable transport system” there is a different picture when looking at the distribution of funding (Figure 14).

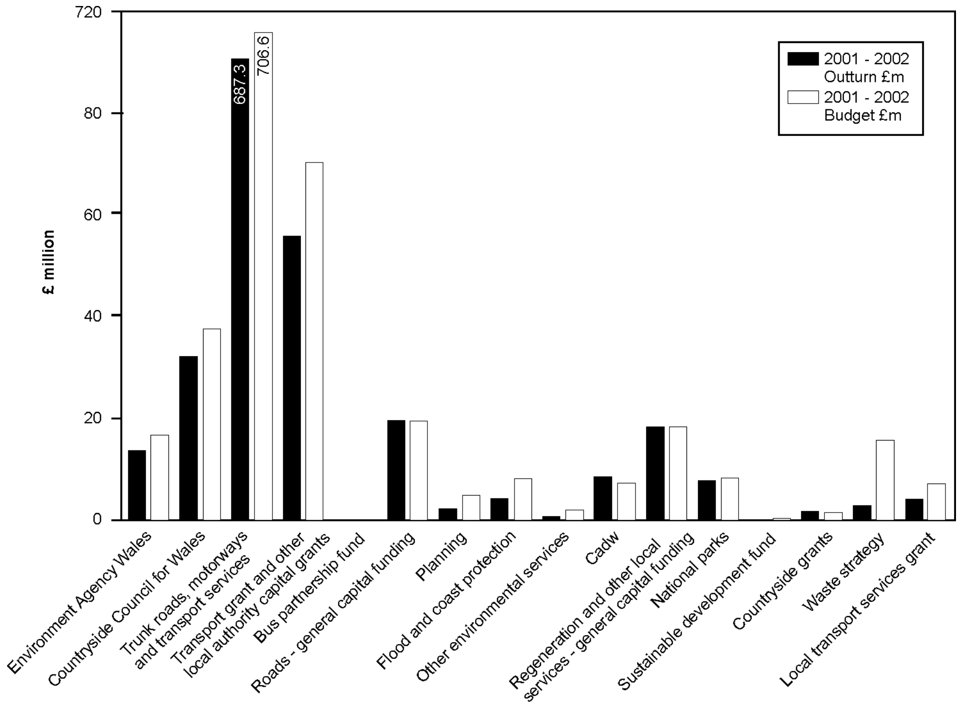

Figure 14: Expenditure on Transport, Environment and Planning[52]

indicates that expenditure on environment, transport and planning grants is dominated by road building. In fact, over 75 per cent of the total funding was budgeted for improving, widening or building of roads.

This raises concerns when taking in account the literature on induced/generated traffic through the building or widening of roads. Since the SACTRA report in 1994, the concept of “Induced Traffic”, otherwise known as “Generated Traffic” has been known and accepted by transport planners. Generated Traffic is the additional vehicle travel that occurs when a roadway improvement increases traffic speeds or reduces vehicle operating costs (SACTRA, 1994[53]; Hills, 1996[54]; Litman, 2001[55]).
This phenomena has been recognised by the UK Government as the quote below by Professor David Begg, Chair of the Commission for Integrated Transport,

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[52] Source of expenditure information: http://www.wales.gov.uk/keypubannualreports2002/content/environment-e.htm#top
[53] SACTRA (Standing Advisory Committee on Trunk Road Assessment), *Trunk Roads and the Generation of Traffic*, UK DoT, HMSO (London), 1994.
[54] Hills P. (1996) , “What is Induced Traffic?” *Transportation*, Vol. 23, No. 1, Feb. 1996, pp. 5-16.
[55] Litman T. (2001), *Efficient Vehicles Versus Efficient Transportation: Comprehensive Comparison of Fuel Efficiency Standards And Transportation Demand Management*, presented at the Transportation Research Board Annual Meeting, 2002, available at the Victoria Transport Policy Institute website (www.vtpi.org).

"But road improvements without measures to deter future traffic growth will result in the service level improvements for users being lost as induced traffic fills up the extra space provided. We will be back at square one all over again."

The literature suggests that increasing urban roadway capacity tends to generate additional peak-period trips that would otherwise not occur. This consists of a combination of *diverted vehicle trips* (trips shifted in time, route and destination), and *induced vehicle travel* (shifts from other modes, longer trips and new vehicle trips). Over time, "Generated Traffic" often fills a significant portion (50-90%) of added urban roadway capacity (Hansen and Huang, 1997[56]; Noland, 2001[57]). Table 48 summarises the results of various studies that measure the amount of added urban roadway capacity that is filled with induced travel.

Table 48: Portion of New Capacity Absorbed by Induced Traffic

Author	Short-term	Long-term (3+ years)
SACTRA		50 - 100%
Goodwin	28%	57%
Johnson and Ceerla		60 - 90%
Hansen and Huang		90%
Fulton, et al.	10 – 40%	50 - 80%
Marshall		76 - 85%
Noland	20 – 50%	70 - 100%

Most studies conclude that the additional road space is "filled" within a three year period. Therefore, the policy of WAG to build an extra 154 kms of roads means that vehicle traffic volumes increase to fill available capacity until congestion limits further growth[58]. Travel that would not occur if roads are congested, but will occur if roads become less congested. Increasing road capacity, or reducing vehicle use by a small group, creates additional road space that is filled with newly generated trips.

This partly explains the suggested increase in passenger kms predicted by WAG. WAG has predicted a continuing growth in road traffic[59]. The Forecasts provide high and low growth rates for all roads within which actual growth is expected to occur. Between 1996 and 2016 the high growth rate is forecasted at 51 per cent, the low growth rate at 23 per cent and a medium growth rate of 38 per cent. Therefore, freeing up "suppressed traffic" through the building and improving of new roads is partly responsible for this increase.

In conclusion, WAG is not only encouraging the use of the car but is actively increasing car traffic. This policy is at variance with the greenhouse gas reduction targets of the Kyoto protocol. As a number of studies have made clear, the implementation of highway schemes alone, without demand restraint or other measures to influence behaviour, will result in relatively short term relief from congestion (as natural traffic growth and induced traffic fill up the spare capacity) and increases in greenhouse gases.

[56] Hansen M. and Huang Y (1997) "Road Supply and Traffic in California Urban Areas," *Transportation Research A*, Vol. 31, No. 3, 1997, pp. 205-218.
[57] Noland, R. (2001) "Relationships Between Highway Capacity and Induced Vehicle Travel," *Transportation Research*, A, Vol. 35, No. 1, January 2001, pp. 47-72; also available at www.epa.gov/tp/trb-rn.pdf.
[58] Source: Personal Correspondence with WAG
[59] WAG (2002) Trunk Road Forward Programme, HMSO.

5.3.2 THE "INTRA-WALES AIR SERVICE"

In March 2004 a consultation document was released by the Welsh Assembly on the proposed Intra-Wales Scheduled Air Service. The Welsh Assembly has made a commitment to develop an integrated and sustainable transport system, within which they see airports and air services playing a vital role. The consultation document has investigated the potential scope for air services in Wales, looked into a number of different route options and passenger forecasts, and considered the associated environmental impacts. It is on this data that the following scenarios are based.

The consultants evaluated the economic viability of intra-Wales scheduled air services, considering potential routes from Aberporth, Caernarfon, Cardiff, Hawarden, Llanbedr, Pembrey, Swansea, Valley, Welshpool and Withybush (Haverfordwest). Four network options were considered in detail. These were a round-Wales service, services focused on Cardiff (a 'Cardiff hub'), various route opportunities outside Cardiff and finally a Cardiff hub with a link to Dublin. The services were not considered likely to give rise to any significant environmental or land use planning impacts.

Interestingly, the consultation document states,

"The services were not considered likely to give rise to any significant environmental or land use planning impacts."

Being aware that planes use fuel and that the burning of fossil fuels emits CO_2, we did not think this was the case. Therefore, the scenario below has calculated the CO_2 emissions and Ecological Footprint of the four different options that are documented in the consultation document.

This conclusion is at variance with a large number of studies of aviation and its environmental impacts, all of which identify severe noise, pollution and climate change impacts from the growth of aviation (Whitelegg and Cambridge, 2004[60]). More importantly the Royal Commission on Environmental Pollution (RCEP, 1994[61]) has concluded that the growth of aviation is inconsistent with the objectives of sustainable development.

For each option the same assumptions have been made. An average occupancy rate of 65 per cent has been used. This is a recognised assumption used for most calculations concerned with air travel. Secondly, it is assumed that the same plane will be used. In the consultation document it is mentioned that a "Dornier 228 aircraft" is likely to be the aircraft of choice for the intra Wales air service. Specific emission factors on this plane have been used (4.2 kg of CO_2 per km). Using GIS the distances travelled between the different airports was calculated.

Option 1 - Round-Wales service

The first option is a round trip starting in Cardiff, on to Valley and Withybush and returning to Cardiff. The following data was generated for the scenario:

- Total distance of one round trip is 506 km
- An average flight distance is 169 km
- Number of passenger is 12,680
- Total distance flown in one year is 164,372 passenger kms.
- Financial loss over a four year period – £ 5.9 million

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[60] Whitelegg J. and Cambridge H. (2004) Aviation and Sustainability, Stockholm Environment Institute.

[61] RCEP (1994) Transport and the Environment. Royal Commission on Environmental Pollution.

This would generate 690 tonnes of CO_2 in one year. This is equivalent to an extra 470 cars being driven 8,673[62] km in a year. Employing the projections in the consultation would increase the emissions to 890 tonnes of CO_2 per year; the equivalent of 606 cars.

Option 2 – The Cardiff Hub

The second option is to travel from Cardiff to Valley or from Cardiff to Swansea. An assumption has been made that passengers would not fly from Cardiff to Swansea as to short a distance. Therefore, Swansea and Cardiff passengers would be travelling to Valley.

- Total distance of one round trip is 998 km
- An average flight distance is 250 km
- Number of passenger is 12,880
- Total distance flown in one year is 247,207 passenger kms.
- Financial loss over a four year period – £ 2.7 million

This would generate 1,037 tonnes of CO_2 in one year. This is equivalent to an extra 705 cars being driven 8,673[19] km in a year. Employing the projections in the consultation would increase the emissions to 1,338 tonnes of CO_2 per year; the equivalent of 910 cars.

Option 3 – The Non Cardiff Routes Opportunities

The third option is to travel from Swansea to Valley or from Valley to Withybush.

- Total distance of one round trip is 349 km
- An average flight distance is 174 km
- Number of passenger is 11,140
- Total distance flown in one year is 149,327 passenger kms.
- Financial loss over a four year period – £ 3.2 million

This would generate 627 tonnes of CO_2 in one year. This is equivalent to an extra 427 cars being driven 8,673[19] km in a year. Employing the projections in the consultation would increase the emissions to 809 tonnes of CO_2 per year; the equivalent of 550 cars.

Option 4 – Cardiff Hub with Dublin

The fourth option is the same as option 2 with an added link to Dublin.

- Total distance of one round trip is 998 km
- An average flight distance is 250 km
- Number of passenger is 15,880
- Total distance flown in one year is 304,786 passenger kms.
- Financial loss over a four year period – £ 2.5 million

This would generate 1,279 tonnes of CO_2 in one year. This is equivalent to an extra 870 cars being driven 8,673[19] km in a year. Employing the projections in the consultation would increase the emissions to 1,650 tonnes of CO_2 per year; the equivalent of 1,122 cars.

It is suggested that all the schemes would create about 80 direct jobs. Therefore, the minimum cost of this job creation would be £7,813 per job per year and maximum would be £18,438 per job per year. In conclusion, the scheme would produce CO_2 emissions between 690 to 1,279 tonnes for the first year and run at a loss of between £2.5 and £5.9 million over a four year period. Emissions would also

[62] This is the average distance that a Wales resident travels by car in one year.

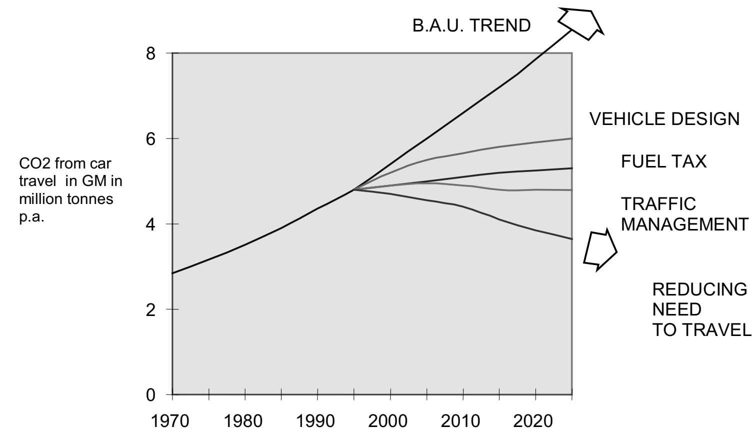
increase by 29 per cent over this four year period. The scheme would increase the annual Ecological Footprint of domestic flights by 7 per cent.

5.3.3 DEMAND MANAGEMENT SCENARIOS

Transportation Demand Management (TDM) is a general term for strategies that result in more efficient use of transportation resources. The options available are endless and can be tailor-made to the location in question. Policies that can affect motorists include car sharing, parking management, parking pricing and congestion charges. To achieve this would need a full policy menu – infrastructure for fuelling and servicing, graduated parking charges, mileage allowances, employer subsidies and tax breaks, purchasing and contracting conditions, and subsidised clean car clubs just to name a few. It would be impossible to discuss all of these in turn, so a few examples have been chosen. The case studies (work place, schools and households) have been selected on the grounds that they have brought about a substantial reduction in the Ecological Footprint.

Figure 15 highlights the projected effects that different technologies and policies can have on climate emissions[63].

Figure 15: Road transport policy options and scenarios



Effects estimated for national & local policy measures on total CO2 (as C)

Source: model results based on Hughes 1994

Figure 15 adequately highlights the impact of alternative sources. While this information has been known for a long time little has been done to reduce the need to travel and a lot has been done to encourage growth.

The literature suggests that "Demand Management" can bring about a 15-20 per cent reduction in car use with shifts away from the car towards public transport, walking and cycling. As transport is the fastest growing source of GHG emissions, urgent attention is needed to manage demand to bring about a reduction in the rate of growth and then an absolute reduction in the amount of GHG.

[63] Hughes, P (1993) Personal Transport and the Greenhouse Effect, London, Earthscan

- Work

The following scenario on changing commuter travel patterns is based on a three-year transport scheme to change the modal split. It is not possible to predict the exact percentage change in the modal split. However, it is suggested that if implemented a change a modal shift in the 20-30 per cent target range can be achieved. The scenario is based on a number of changes that businesses can undertake to encourage a transportation transformation. It is suggested that support from WAG could be provided to encourage businesses to adopt the following suggestions and in some cases, financial support to accelerate change.

Car sharing is often one of the most successful areas of modal shifting, because it involves a less drastic change from the culture of car-borne travel behaviour. At present, it is estimated that only 14 per cent of the commuters are car sharing[64]. Previous studies, conducted by Whitelegg (1998[65] & 1999[66]) indicate that 47 per cent of the total commuters are prepared to consider car sharing. There appears to be the scope for expanding car sharing within Wales. Car sharing is perceived to work best when hours are fixed, therefore suggesting that key industries should be targeted as opposed to blanket policy.

Measures to improve the attractiveness of car sharing could increase its use, but the extent of this effect is difficult to judge. Existing low levels of sharing could indicate a high potential for further growth.

To help inaugurate a car-sharing scheme several incentives can be put in place to assist this process:

- Guaranteed ride home: this was introduced by Boots, to overcome the fear of the lift failing by guaranteeing a taxi ride home in such an eventuality.
- Car share advice scheme: this would provide commuters with all the necessary information on car sharing, including a computerised database to put people in touch with other commuters living in the same area.
- Preferential parking facilities: car sharers can be allocated the best parking places closet to the offices, and be offered free parking where charging will be put in place.

Levying a charge for workplace parking is a potential tool in encouraging modal shifts in travel behaviour, by increasing the cost of travel by car thereby decreasing the car's financial attractiveness relative to other modes. In the UK government support of workplace travel plans through the provision of free consultancy services to the client have produced significant reductions in car use and increases in car-share, public transport and walk/cycle use. In most cases a modest charge for car parking has been found to be very significant in shifting car trips to the alternatives. A charge sends a strong financial signal to the commuter that a policy is in place to reduce car use and the income from charges has been ring fenced to produce very attractive discounts on public transport use.

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[64] National Travel Survey, 2002

[65] Whitelegg J. (1998) *Pfizer Sandwich Company Transport Plan*, John Whitelegg Associates, Lancaster.

[66] Whitelegg J. (1999) *The Chase Farm Hospital Transport Plan*, unpublished.

- School

Over 47 per cent of all school trips are carried out by car. This offers an opportunity to reduce the Ecological Footprint of the school run substantially with the introduction of ‘walk to school schemes’, school bus services, and cycle-friendly routes for school children. Only a small percentage of school children would not be able to benefit from one of these three schemes. There is no reason why an integrated transport system could not accommodate all the schools.

School based travel plans have seen reductions in CO_2 emissions in the region of 30 per cent.

- Households

The importance of changing travel behaviour in the UK is widely recognised as being an essential element of an overall package of measures designed to solve transport problems. Intelligent Travel aimed to examine the potential for changing travel behaviour by reducing car use and encouraging walking, cycling and public transport use, which promote health, fitness and a better environment. It tested personalised travel planning on a random sample of 5,701 households living in three wards of the City of York, using before and after questionnaire surveys to measure the effect on personal travel behaviour[67].

The York Intelligent Travel project achieved a 16-percentage point reduction in car trips and a 28 per cent reduction in car distances driven. This equates to 15,000 fewer cars on the city’s road if half the population of York took part in the scheme. Walking and public transport increased by 10 and 5 percentage points respectively. In the context of national and international transport planning and policy this is remarkable result. It shows that it is possible to influence travel choices away from the car and away from short trips by car. It has been achieved in a constructive and co-operative manner simply through close working with local residents.

[67] A full copy of the Intelligent Travel Report can be downloaded from: www.sei.se/intelligenttravel

5.4 Conclusions

This chapter has shown that transport accounts for a significant proportion of the total Ecological Footprint (15 per cent). Transport's greenhouse gas emissions form a large part of this and these are likely to rise even faster in the future as the UK and devolved administrations allocate significant resources to expanding road and airport capacity. Both UK and EU policy in this area call for higher levels of policy integration. This means that transport policy should contribute to achieving greenhouse gas reductions and to improvements in air quality and ambient noise levels. Currently this is not the case and transport policy is to a large measure in contradiction to sustainable development policy measures (Royal Commission on Environmental Pollution, 1994).

This need not be the case. There is considerable potential in Wales to reduce the use of the car for the journeys to both work and to school. This will contribute to the reduction of congestion and to the improvement of economic performance through less time lost in congested traffic. There is the possibility to reduce the demand for aviation through rail substitution and through video-conferencing and other forms of new electronic technology. It is very unlikely that the expansion of aviation in Wales could contribute to sustainability and its development should be subjected to a thorough Strategic Environmental Assessment.

There is considerable potential to adopt sustainable corridor transport policies in an east-west direction in North, Mid and South Wales and to adopt European best practice in rural public transport provision to give Welsh citizens who do not live in urban areas high quality access to educational, social, recreational, training and work opportunities[68].

Most of the journeys made by Welsh citizens are less than 10 miles in length and most of these journeys can be made reliable, safe, attractive, sustainable and rewarding with investments in walking, cycling and public transport. This will also bring significant gains for the poor, the elderly, women, children and other groups not well served by high cost investments in highway infrastructure and aviation.

Wales can either adopt (implicitly or explicitly) a business as usual scenario based on the expansion of environmentally damaging modes of transport (car, lorry and air) supported by new highway and aviation infrastructure, or it can move in the direction of sustainability in transport policy based on re-balancing modes and reallocating budgets in favour of sustainable transport options.

[68] Rural Transport Futures: transport solutions for a thriving countryside, ed L Sloman, Transport 2000 and the Countryside Agency, 2003

6. Built Environment

6.1 Results

The construction sector – buildings, infrastructure and the built environment generally – is the largest single material user, waste generator and energy user. It also has a massive inertia, as only 1–2% of the total built stock is renewed in any one year.

This section looks at the practical issues in steering the construction of the built environment in Wales towards a reduced Ecological Footprint and greater sustainability. With many environmental, economic and social angles to explore, we can sketch here only the key features at different scales. The starting point is the 'micro-scale' – the design, materials and material sources for the building fabric. This fits into the context at the 'macro-scale' – the location, density and form of urban development and building types. The time element is also crucial and the comparison between building construction and buildings in use – for example, whether it is better to replace older buildings by newer ones with improved energy efficiency.

For a strategic overview of the sustainability implications of housing in Wales, see the WWF/CRIBE report "Building a Future for Wales".

6.1.1 RESULTS FROM THE MATERIAL FLOW ANALYSIS

Consumption of construction materials in Wales

Overview

The input-output analysis employed in this project allows the allocation of material flows to final consumption activities (see Appendix). This means for example, that it is possible to identify the materials that are related to construction activities, i.e. to map out a picture of infrastructure related material flows.

Table 49 shows the amount of construction related materials that were consumed by all final consumers in Wales in 2001. The table is split in two parts: materials that are known to be used mainly or exclusively for construction purposes and materials that can be used for various products and purposes, including construction. The table shows the 'responsibilities' for the consumption of materials. According to their expenditure pattern the final consumers are responsible for the flow of certain materials but this does not necessarily mean that they 'own' all the materials that are listed in Table 49. If a household for example spends money on 'hotels and catering', then the corresponding amount of cement that went into building the hotel or restaurant is taken into account. Further below we show how those materials can be identified that are used to actually build or maintain private housing (see Table 50).

Due to data and time constraints, the material flows for government infrastructure and business/industry infrastructure were calculated pro rata from UK data, i.e. they are proportional to population. Implicitly, this procedure assumes that the responsibility for public and industrial infrastructure is shared equally amongst the population of the UK.

The second last column shows construction materials that are related to exports from Wales. Again, these are materials that are related to export activities and they do not necessarily leave the country. From UK data it is known that approximately 40% of the materials assigned to economic export activities are actually physically exported overseas.

Apart from exports most of the construction related materials (10.3 million tonnes or 3.5 tonnes per capita) are consumed by business and industry infrastructure. Private households in Wales account for the consumption of 3.9 million tonnes of construction related materials (1.34 tonnes per capita).

Table 49: Total final consumption of construction related materials in Wales (all numbers in thousands of tonnes, kt)

kt		Final consumption category >>	Households	Central & local government	Capital investment, valuables, inventories, NPISH	Exports	
EA code	123 code	**Type of infrastructure >>** / **Type of material**	**Infrastructure used by households**	**Government (public) infrastructure**	**Business and industry infrastructure**	**Export related materials** a)	**Total MF per economic sector**
		Mainly used as construction material					
7	7	Aggregates (other mining …)	1,749	439	6,042	8,774	**17,005**
34	51	Structural clay products	65.1	22.8	330	35.0	**453**
35	52	Cement, lime and plaster	229	108	372	179	**887**
36	53	Articles of concrete & stone	963	317	2,617	786	**4,683**
		Partly used as construction material					
13	31	Wood and wood products	247	42.9	260	148	**698**
25	42	Paints, varnishes, etc.	45.2	11.8	29.0	56.0	**142**
30	47	Rubber products	34.5	3.98	9.8	30.7	**79**
31	48	Plastic products	136	21.2	91.2	125	**373**
32	49	Glass and glass products	68	14.9	51.7	75.8	**211**
33	50	Ceramic goods	42.8	7.25	28.7	45.9	**125**
37	54	Iron and steel	219	42.4	277	669	**1,207**
41	57-61	Structural metal products	89.4	19.2	159	139	**406**
		Total MF per final consumption category	**3,887**	**1,051**	**10,267**	**11,063**	**26,269**
		Total MF per capita [t/cap]	1.34	0.36	3.53	3.80	9.03

a) An estimated 60% of these materials actually don't leave the country as this category includes export of services and indirect material flows associated with export activities.

Construction materials for private housing in Wales

An in-depth analysis of the material flows shown in Table 49 allows to extract the materials that are purely used for construction related purposes. This includes the building of new houses but also the repair and maintenance of the existing housing stock. In order to identify the relevant material flows it was analysed in more detail *what* the materials are used for ('construction related activities') and *where* these materials come from ('…through sector…'). The following COICOP categories from the household consumption list were identified as being particularly related to construction activities:

- COICOP 04.1: "Actual rentals for housing"
- COICOP 04.2: "Imputed rentals for housing"
- COICOP 04.3: "Maintenance and repair of the dwelling"

In terms of where the materials come from three relevant routes have been identified:

- directly through the sector that produces the material
- indirectly through the sector 'Construction'
- indirectly through the sector 'Owning and dealing in real estate'

Table 50 shows the results of the analysis. In total, almost 1 million tonnes (988kt or 340kg per person) were used in 2001 in Wales to build new homes or repair and maintain existing homes. This is 25 per cent of the total use of construction related materials, i.e. three quarters of the total material flow of 3,890kt are not used for private housing but for other infrastructures that are used by households or for other purposes (for example, wood is also used for furniture, steel is also used for cars, etc.). Nevertheless, households are indirectly responsible for the consumption of all of these materials.

It is obvious that the 'construction related activities' represent materials that are directly used for construction as they account for 99 pre cent of the material flows associated with the sectors 'Construction' and 'Owning and dealing in real estate'. For the direct flows of materials, this column accounts for the proportion of the material flow that is actually used for construction purposes. In total only 27% of all wood products are used for construction. Of this 27 per cent, 69 per cent were directly bought from the 'Wood and wood products' industry. Aggregates represent the bulk of construction materials with 440kt, followed by articles of concrete and stone with 318kt.

Table 50: Analysis of construction material flows related to household consumption and private housing (all numbers in thousand tonnes, kt)

Economic sector	Total infrastructure materials used by households	Construction materials directly used for private housing (construction related activities, COICOP 04.1+04.2+04.3)	% used for construction
Total consumption of aggregates	**1,750**	**440**	**25.1%**
...directly through sector 'Other mining & quarrying'	-	-	
...indirectly through sector 'Construction'	119	119	99.6%
...indirectly through sector 'Owning & deal. in real estate'	271	268	98.9%
...indirectly through sector 'other sectors'	1,359	53.3	3.9%
Total consumption of wood and wood products	**247**	**65.7**	**26.6%**
...directly through sector 'Wood and wood products'	52.6	36.4	69.3%
...indirectly through sector 'Construction'	6.63	6.61	99.6%
...indirectly through sector 'Owning & deal. in real estate'	19.3	19.1	98.9%
...indirectly through sector 'other sectors'	168	3.64	2.2%
Total consumption of paints, varnishes, etc.	**45.2**	**8.24**	**18.2%**
...directly through sector 'Paints, varnishes, printing ink etc'	3.56	3.41	95.9%
...indirectly through sector 'Construction'	0.61	0.61	99.6%
...indirectly through sector 'Owning & deal. in real estate'	2.82	2.79	98.9%
...indirectly through sector 'other sectors'	38.2	1.43	3.7%
Total consumption of rubber products	**34.5**	**2.11**	**6.1%**
...directly through sector 'Rubber products'	11.97	0.37	3.1%
...indirectly through sector 'Construction'	0.09	0.09	99.6%
...indirectly through sector 'Owning & deal. in real estate'	1.03	1.01	98.9%
...indirectly through sector 'other sectors'	21.5	0.63	3.0%
Total consumption of plastic products	**136**	**21.8**	**16.1%**
...directly through sector 'Plastic products	17.1	10.1	59.3%
...indirectly through sector 'Construction	1.88	1.88	99.6%
...indirectly through sector 'Owning & deal. in real estate'	6.96	6.88	98.9%
...indirectly through sector 'other sectors	109.6	2.94	2.7%
Total consumption of glass and glass products	**68.2**	**5.58**	**8.2%**
...directly through sector 'Glass and glass products	12.2	0.00	0.0%
...indirectly through sector 'Construction	0.88	0.88	99.6%
...indirectly through sector 'Owning & deal. in real estate'	2.76	2.73	98.9%
...indirectly through sector 'other sectors	52.3	1.97	3.8%
Total consumption of ceramic goods	**42.8**	**3.17**	**7.4%**
...directly through sector 'Ceramic goods	30.0	0.01	0.0%
...indirectly through sector 'Construction	0.66	0.66	99.6%
...indirectly through sector 'Owning & deal. in real estate'	1.73	1.71	98.9%
...indirectly through sector 'other sectors	10.4	0.79	7.6%
Total consumption of structural clay products	**65.1**	**24.6**	**37.9%**
...directly through sector 'Structural clay products	-	-	
...indirectly through sector 'Construction	7.63	7.60	99.6%
...indirectly through sector 'Owning & deal. in real estate'	16.6	16.4	98.9%
...indirectly through sector 'other sectors	40.8	0.6	1.4%
Total consumption of cement, lime and plaster	**229**	**72.3**	**31.6%**
...directly through sector 'Cement, lime and plaster	28.9	28.9	100.0%
...indirectly through sector 'Construction	9.58	9.55	99.6%
...indirectly through sector 'Owning & deal. in real estate'	25.3	25.0	98.9%
...indirectly through sector 'other sectors	165	8.87	5.4%
Total consumption of articles of concrete & stone	**963**	**318**	**33.1%**

Economic sector	Total infrastructure materials used by households	Construction materials directly used for private housing (construction related activities, COICOP 04.1+04.2+04.3)	% used for construction
...directly through sector 'Articles of concrete, stone etc	56.7	28.1	49.5%
...indirectly through sector 'Construction	82.8	82.5	99.6%
...indirectly through sector 'Owning & deal. in real estate'	182	180	98.9%
...indirectly through sector 'other sectors	641	27.5	4.3%
Total consumption of iron and steel	**219**	**16.9**	**7.7%**
...directly through sector 'Iron and steel	-	-	
...indirectly through sector 'Construction	1.62	1.62	99.6%
...indirectly through sector 'Owning & deal. in real estate'	9.48	9.37	98.9%
...indirectly through sector 'other sectors	207.6	5.90	2.8%
Total consumption of structural metal products	**89.4**	**9.42**	**10.5%**
...directly through sector 'Structural metal products	8.91	1.35	15.2%
...indirectly through sector 'Construction	1.14	1.13	99.6%
...indirectly through sector 'Owning & deal. in real estate'	4.55	4.50	98.9%
...indirectly through sector 'other sectors	74.8	2.44	3.3%
Total material flows [kt]	**3,887**	**988**	**25.4%**
Total MF per capita [t/cap]	**1.34**	**0.34**	

If the total consumption of construction materials for private homes is divided by the number of newly built homes in Wales in 2001, the average 'weight' of a home is 116 tonnes. However, this number includes the repair and maintenance of existing homes and therefore would be lower for an actual new home.

Construction materials for public and industrial infrastructure in Wales

As mentioned above it was assumed that there is equal responsibility for 'shared' infrastructure such as road, bridges, office buildings, industrial facilities, etc. Within the scope of the project it was not possible to collect and analyse more regionally specific data on this type of infrastructure. Therefore, the numbers in Table 51 represent the Welsh share of responsibility for material flows in government and business/industry construction activities in the UK.

10 million tonnes of construction related materials are used to built infrastructure for offices, companies, industrial plants, etc. Roughly half of these materials are delivered by the construction sector whereas the other half is related to other economic sectors.

Government infrastructure requires about 1 million tonnes of materials that are not directly delivered by the construction sector but the flow of these materials rather occurs through sectors the governments spend money on; mainly public administration and defence, education and health and other public services.

Table 51: Analysis of construction material flows related to public and business or industrial infrastructure (all numbers in thousand tonnes, kt)

Final consumption category >> **Material or economic sector**	Central & local government **Government infrastructure**	Capital investment, valuables, stock changes, NPISH **Business and industry infrastructure**
Total consumption of aggregates	**439**	**6,042**
...through sector 'Construction'	-	3,257
...through other sectors	439	2,786
Structural clay products	**22.8**	**330**
...through sector 'Construction'	-	211
...through other sectors	22.8	119
Cement, lime and plaster	**108**	**372**
...through sector 'Construction'	-	248
...through other sectors	108	124
Articles of concrete, stone etc	**317**	**2,617**
...through sector 'Construction'	-	2,242
...through other sectors	317	375
Wood and wood products	**42.9**	**260**
...through sector 'Construction'	-	170
...through other sectors	42.9	90.1
Paints, varnishes, printing ink etc	**11.8**	**29.0**
...through sector 'Construction'	-	15.8
...through other sectors	11.8	13.3
Rubber products	**3.98**	**9.80**
...through sector 'Construction'	-	2.46
...through other sectors	3.98	7.33
Plastic products	**21.2**	**91.2**
...through sector 'Construction'	-	48.2
...through other sectors	21.2	43.0
Glass and glass products	**14.9**	**51.7**
...through sector 'Construction'	-	23.5
...through other sectors	14.9	28.2
Ceramic goods	**7.3**	**28.7**
...through sector 'Construction'	-	17.8
...through other sectors	7.3	10.9
Iron and steel	**42.4**	**277**
...through sector 'Construction'	-	43.8
...through other sectors	42.4	233
Structural metal products	**19.2**	**159**
...through sector 'Construction'	-	30.1
...through other sectors	19.2	129
Total material flows [kt]	**1,051**	**10,267**

6.1.2 ECOLOGICAL FOOTPRINT RESULTS

The Ecological Footprints associated with living in houses and with general infrastructure were calculated. The results can be shown in two different ways: footprint per number of houses (breakdown A) or footprint per housing related activity (breakdown B) (see Table 52, together with other housing relevant statistics).

Table 52: The Ecological Footprint of housing and general infrastructure in Wales and the UK in 2001

	UK	Wales	Unit
Population (revised 2001 mid-year estimates)	58,836,700	2,907,600	no. of people
Stock of dwellings (2001)	25,382,000	1,274,164	dwellings
Stock of dwellings per population	0.43	0.44	dwellings/cap
Housebuilding completions (2001)	177,400	8,530	dwellings
Housebuilding completions per population	0.0030	0.0029	dwellings/cap
Construction sector employees (2001)	1,769,655	84,063	no. of people
Ecological Footprint of private housing (breakdown A)			
EF for new houses in 2001	0.0012	0.0012	gha/cap
EF for housing stock	0.173	0.165	gha/cap
Ecological Footprint of private housing (breakdown B)			
Actual rentals for housing (COICOP 04.1)	0.033	0.034	gha/cap
Imputed rentals for housing (COICOP 04.2)	0.075	0.076	gha/cap
Maintenance and repair of the dwelling (COICOP 04.3)	0.067	0.057	gha/cap
Ecological Footprint of general infrastructure			
EF for capital investment (gross fixed capital formation) [a)]	0.744	0.744	gha/cap

Data sources: Welsh Housing Statistics 2001 (http://www.wales.gov.uk/keypubstatisticsforwales/housing/housing.htm); ONS "Dwelling Stock by Country and Region"; ONS statistics on housing (http://www.statistics.gov.uk/statbase/datasets2.asp?th=3&B1=Show+Linked+Datasets); ONS Census 2001: Table KS11a Industry of employment; http://www.cic.org.uk/information/state.htm

a) The final demand category 'capital investment' accounts for most of the construction materials used for general infrastructure (see section 7.1.1 for details).

About one third of the Ecological Footprint for housing is due to maintenance and repair work, whereas the remaining two thirds represent the impact of owning or renting a home. Although there are slightly more dwellings per capita in Wales than in the UK the total footprint for private housing is still lower because the impact of maintenance and repair in Wales is significantly lower.

The Ecological Footprint per capita for general infrastructure is the same for the UK and for Wales because a shared responsibility was assumed like for material flows (see section 7.1.1).

6.2 Policy Implications

6.2.1 WELSH POLICY CONTEXT

Demand for construction products and services derives from the need to maintain, replace and add to over 1 million homes, 100,000 other types of building and the transport and service infrastructure that sustain local economies and communities across Wales. The industry provides over 70,000 jobs, accounting for 8% of the Welsh economy[69].

The UK government recognises that creating a better country through sustainable development depends heavily on the construction market moving rapidly from current practices to more sustainable procurement and supply. Subsequently, a strategy for more sustainable construction 'Building a Better Quality of Life', was published in April 2000 and documented the following points:

1) Identified priority areas for action including: minimising waste production and energy use through design and lean construction, minimising pollution, enhancing biodiversity, conserving water, respecting people and the local environment, and monitoring and reporting.
2) Emphasised the importance of targets and indicators to measure progress.
3) Encouraged the construction industry to actively adopt more sustainable practices.

This was further reinforced by the amendment of the Buildings Regulations in 2000 and again in 2004 to ensure not only the provision of functional requirements for building design and construction but also energy conservation, in line with the EU's Directive on the Energy Performance of Buildings. In 2002 the WAG published 'Technical Advice Note 12: Design' a planning guidance report with detailed advice on achieving good design within the Welsh planning system outlined in 'Planning Policy Wales'. An action plan for the construction industry in Wales titled 'Starting to Construct Differently' followed in 2004.

While the government shapes the legislative, fiscal and general public policy framework within which construction delivers the country's infrastructure, it cannot implement it alone. The support and cooperation of the industry and its stakeholders, including clients, suppliers and the users of the constructed products is crucial to its success. The construction industry responded with a review of Government research and development, policies and practices with 'Rethinking Construction Innovation and Research' in 2002 - a report that has become the banner under which the government, industry and its clients are working together for change and improvement in construction performance. The construction industry have also formed the Sustainability Forum, which has been charged by the Department of Trade and Industry's Construction Sector Unit to investigate and make recommendations on improving take up of sustainable development within the construction and property sectors. There is also Constructing Excellence, a limited company that brings together Rethinking Construction and the Construction Best Practice Programme under the one umbrella to deliver construction industry reform.

6.2.2 KEY POLICY OBJECTIVES & TARGETS

'Starting to Construct Differently' documents a review of consultations and a plan for action towards a sustainable knowledge based construction industry in Wales, including a sustainable construction action plan and a review of research and best practice. Eleven separate themes for action along with

[69] Starting to Construct Differently: Action Plan for the Construction Industry in Wales (2004) Constructing Excellence in Wales and WDA Cardiff University Mandix.

five priority areas for action, “to ensure a thriving construction industry that makes Wales the envy of the world by 2010”[1] were identified by the group workings. See Table 53 for details.

Table 53: The Key Themes outlined in the sustainable construction action plan for Wales ‘Starting to Construct Differently’ (2004).

The 11 Themes in ‘Starting to Construct Differently’
Procurement: WAG Strategy and policy needs to recognise that public sector purse holders can lead positive change in industry culture and behaviour. Procurement needs rethinking as a process that views construction as a service that is performed best by stable long term supply chain partnerships committed to delivering quality, efficiently, to time and cost in a way that protects the environment and enhances social capital.
Business improvement services: SMEs and micro businesses need help to gain and maintain preferred supplier status in supply chain partnerships that are stable, where continuous improvement is a goal and provisions for consultation and learning are built in. Stable partnerships are required to meet growing producer accountability for social and environmental impacts.
Infrastructure: Action is needed by public and private sector investors to ensure coherence between plans. Agreements on spatial allocations are essential to deliver holistic, resource efficient solutions to development needs and opportunities.
Communication: Action is needed to communicate desire for and commitment to sustainable construction, and give visibility to public and private sector leadership towards defined objectives that provide direction for policies on partnering and best value to enable change that can be measured, monitored and reported
Measuring and monitoring: The industry needs to agree standards that all stakeholders recognise and value. There should be a move away from the notion of measuring immediate success towards time series on economic, social and environmental data to establish industry trends and trajectory towards (or away from) sustainable development.
Innovation: The industry needs to create a ‘framework for change’ that enables thinking ‘beyond the building’ and focuses on how innovation can be delivered in areas including self-build, refurbishment and retrofit. It needs to encourage forums to link innovation and quality and identify opportunities to develop new technologies, products and processes especially in relation to "offsite manufacture".
Leadership: Action is needed to stimulate demand that is globally aware as well as locally focused. Clients and suppliers need to raise their expectations and demands to stimulate the creativity, innovation and experimentation needed to deliver change. A clear programme is needed to encourage buy-in from key stakeholders and create the organisational Infrastructure needed to build capacity
Organisational Infrastructure: Action is needed to build on and integrate existing provisions so that the industry acquires a system of funding that is coherent with the support services needed to build the capacity able to meet higher expectations. There needs to be a clear organisation linking research and demonstration projects, training, systems for knowledge sharing and exchanges for recycled materials amongst other issues.
Education and promotion: Action is needed for the industry and for the consumer. People are a key focus - their education and training whether blue collar or white collar, skilled or unskilled. Needs must be identified and provided for especially in relation to new technologies. The industry needs to be constantly acquiring better installation, training, management and technical skills.
Incentives: Sustainable construction will require change at a pace beyond the capacity of the current market to deliver. There needs to be incentives for change that involves carrots as well as sticks – funding support must be available for investment in change. Industry capacity needs building to meet rising expectations and to put it on a trajectory that is sustainable.
Demonstration: Action is needed to demonstrate economic solutions particularly local best value solutions.

Design – specification, technology. Not every project can solve every problem so start with demonstrating partial solutions – 'Just Do It'
Identified Top Priorities For Action
Educate the stakeholder that the cheapest solution is not necessarily the most sustainable: This requires dissemination of case studies based on the use of Key Performance Indicators, including costs, and the identification of 'champions' in the client cadre who will participate in briefing meetings with other procurers of construction products and services.
Partnering is needed to support sustainable construction: Partnering needs to involve government and local authorities and projects need to be bigger and longer. It needs to be made more practically relevant and better explained in terms of leadership, developing people, education and champions.
Address the skills shortage in Wales: Take a different perspective in Wales. Go for the knowledge based high value end of the construction market. This is about marketing and communication including using education programmes. It is about paying attention to salaries, developing apprenticeship schemes and developing specialised markets
Innovation: There is a need to discover how we change the way we do/think now in order to get the industry on a trajectory that is sustainable.
Leadership – globally policed but locally aware: WAG should provide high level leadership to monitor, audit and report on progress towards sustainable construction and there is a need to create an 'advisory hub' for stakeholders (including the WDA) that is valued by WAG as a standard setter.

6.2.3 EF IMPLICATIONS

Buildings and structures change the nature, function and appearance of our towns and countryside and have helped define the social, economic, environmental and cultural makeup of Wales. But, the very industry that has helped create the Wales we know is also the largest single material user, waste generator and energy user. The consumption of such resources does not end with the production of the final good. Instead, it continues throughout the lifespan of the infrastructure while it is being used, repaired, maintained and finally demolished. The action plan for the construction industry in Wales has acknowledged that current practices need to evolve in order to sustain an efficient, effective and responsible industry that is sensitive to the present and future needs of Wales. The eleven separate themes and five priority areas highlighted in 'Starting to Construct Differently' (Table 53) certainly provide a starting point for local specific action to take place. Currently, from a sustainability context, Building Regulations and Planning Policy are the primary authority in the industry. But how much of an impact do they have on the Ecological Footprint?

The two scenarios that have been explored in the following sections provide an analysis and some answers to this question. As one of the most critical infrastructures determining the quality of life lead by people is their home and it's surrounding environment, this infrastructure is central to the scenarios. For most people, their homes are the foundation upon which their everyday life is based, providing a safe and comfortable haven, shelter from the elements and good amenities in a safe and congenial neighbourhood[70]. Therefore, the first scenario looks at the Ecological Footprint of different build home types and the second at the Ecological Footprint of building new dwellings. The analysis presented should provide an insight into the effectiveness of current Building Regulations as well as an indication of the direction which the Welsh construction industry action plan could take in the future in order to become the "envy of the world by 2010".

[70] Better Homes for People in Wales: A national housing strategy for Wales (2001) NAfW

6.3 Future Scenarios

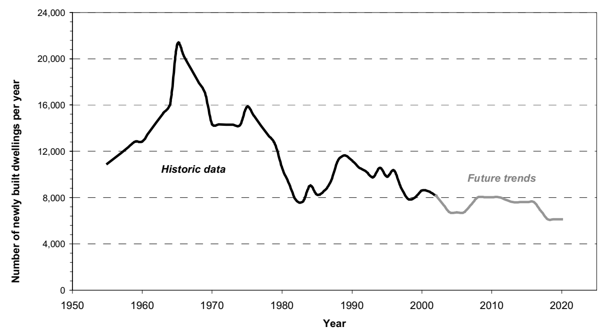
6.3.1 KEY SCENARIO INDICATORS

Living in houses is associated with both the use of energy and the consumption of construction materials. While it takes a considerable amount of energy to produce, transport and assemble construction materials, it is generally the use of energy to heat and light the house that requires the bulk of energy during the lifetime of a house. Therefore, the consumption of ***energy*** must be included along with ***building materials*** in any meaningful scenario for housing. As described in section 7.3.3, three different scenarios have been selected to demonstrate the effect of different policies and developments on the energy and the housing infrastructure footprint.

6.3.2 FUTURE TRENDS AND DRIVING FORCES

In the last 40 year the stock of dwellings in Wales has grown by over 60% from 782,000 dwellings in 1961 to 1,282,000 in 2002[71]. The growth is predicted to continue for the next 15 year – albeit at a slower rate – and the dwelling stock is expected to be over 1.4 million by 2020 (see Figure 16). Parallel to an expected increase of population in that time period, the numbers of households is expected to increase mostly in Mid Wales (by 16.6 per cent) and South East Wales (15.2 per cent). The average household size is expected to level out to 2.24 persons across Wales (in Great Britain, the average household size dropped from 2.9 to 2.4 in the last 30 years).

Thus, two main driving forces can be identified for a growth in housing stock in Wales: more people living in Wales and less people living in one house.



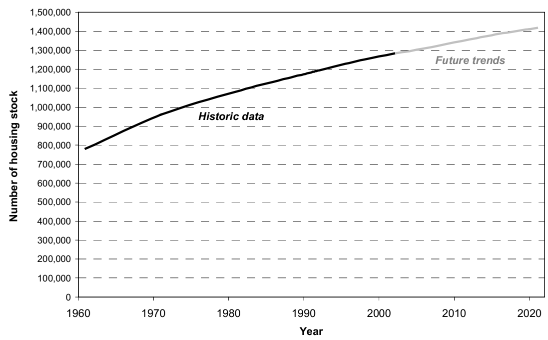


Figure 16: Historic and estimated future trends of new house building (left) and housing stock (right) in Wales

6.3.3 FUTURE SCENARIOS FOR PRIVATE HOUSING IN WALES

In the following, two scenarios are presented that explore the impacts of different types of houses and potential reductions of the Ecological Footprint if more environmentally friendly homes were built in Wales. A scenario on the potential benefits of improving the energy efficiency of existing houses can be found in the energy chapter of this report (Chapter 4).

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[71] General data source for statistics in this section: http://www.wales.gov.uk/keypubstatisticsforwales/housing/housing.htm

Scenario 1: Ecological Footprint for different types of homes

This scenario includes a comparison, in Ecological Footprinting terms, between a home built to 2002 Building Regulations, a home achieving a BRE[72] EcoHomes 'excellent' rating and a home at the pioneering BedZED eco-village development[73] that has been designed not to consume any fossil energy[74]. A typical home in Wales is also assessed to give an indication of the performance of the vast majority of existing stock. The Ecological Footprints for the key indicators 'domestic energy use' and 'building materials' of all homes have been calculated. Technical improvements in energy efficiency have been taken into account but otherwise no differences in lifestyles of residents have been assumed (for energy consumption in homes please also refer to Chapter 4 "Energy"). Table 54 gives a summary of the four home types for which Ecological Footprints were calculated.

Table 54: The four homes types considered in scenario 1

Acronym	Description of home type	Energy consumption pattern
'Wales average'	based on BRE data for 100 homes	Welsh average consumption pattern
'2002 regulation'	built to 2002 Building Regulations	Welsh average consumption with slightly reduced energy consumption
'EcoHome'	BRE EcoHomes with 'excellent' rating	reduced consumption mainly due to technical efficiency improvements
'BedZED'	BedZED eco-village development	clearly reduced consumption due to specific BedZED conditions

Figure 17 depicts the results from the Footprint calculations and Table 55 shows the Footprint reductions compared to an average home in Wales in percent.

72 Building Research Establishment Ltd
73 http://www.bioregional.com, follow the link to 'BedZED & Eco-Village Development'
74 For further details on input data, assumptions and the calculation methodology for this scenario please refer to the report 'Sustainability Rating for Homes - The Ecological Footprint Component' that is downloadable from the website: http://www.regionalsustainability.org

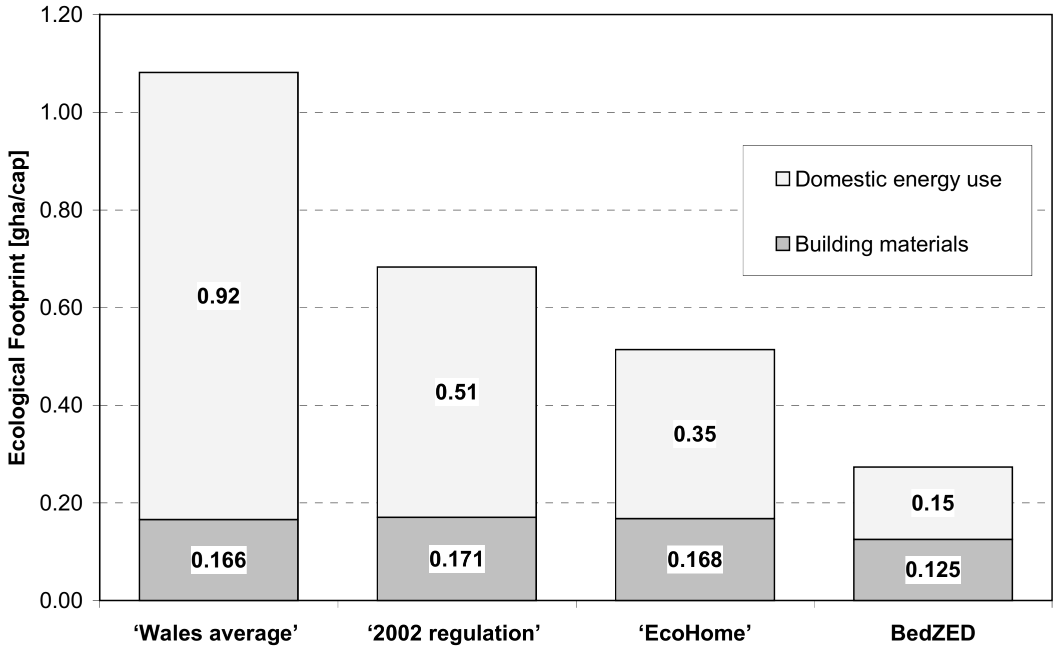

Figure 17: Ecological Footprints of domestic energy use and building materials of different home types

The greatest Ecological Footprint reductions can be achieved in the energy component. Compared to the average energy consumption in an average Welsh home, less energy is used in homes built according to the 2002 building regulations and in EcoHomes where energy efficient lights and appliances, good insulation and condensing boilers are used. The building regulations from 2002 already have a considerable effect and reduce the energy footprint by 44%. BRE EcoHomes achieve a further reduction (-62% compared to the 'Wales average'). In BedZED units energy use for space heating and hot water is reduced by over 90%, whereas energy consumption for cooking, lights and appliances is reduced by 30%. This leads to a total energy footprint reduction of 84% compared to the 'Wales average'.

Table 55: Changes of Ecological Footprints for different types of homes versus a 'Wales average' home

Ecological Footprint component	'2002 regulation'	'EcoHome'	'BedZED '
Domestic energy use	-44%	-62%	-84%
Building materials	+3%	+1%	-24%

Data on building materials for the different home types are estimates from BRE and Bioregional Development Group or were calculated from the actual material consumption of the BedZED scheme. As the results in Figure 17 show, the Ecological Footprints of a new home ('2002 regulation' and 'EcoHome') are slightly higher than the 'Wales average'. This is because some of the materials used have a slightly higher embodied energy content, e.g. special insulation materials. This small increase however is by far more than compensated by the overall reduction in energy (and thus fossil fuel) consumption. The material footprint of the BedZED units is lower than those for the other home types (0.125 gha/cap in one year compared to 0.166 gha/cap in one year for the average Welsh home). This is due to an assumed lifetime of 90 years for the BedZED scheme whereas the average Welsh home is estimated to be in use for 60 years.

The results clearly show that energy efficiency in construction pays off. The reductions in the energy footprint substantially contribute to the overall reductions in environmentally friendly homes, especially in the BedZED scenarios.

Scenario 2: Ecological Footprint for new dwellings in Wales

Three possible pathways for the time up to 2020 (scenarios 2a-c) have been explored in order to assess the effects that different housing policies could have on the Ecological Footprint of new homes in Wales:

- **Scenario 2a ("2002 regulation")**: assumes that from 2002 all new homes from are built according to the 2002 Building Regulations. It further assumes that no better standards will be introduced until 2020. Hence, this scenario reflects the 'business-as-usual' or 'worst' case as a reference point. In reality, it is likely that there will be further improvements to building regulations over coming years.
- **Scenario 2b ("More EcoHomes")**: assumes that within the next ten years it will gradually become mandatory to build new homes according to the BRE EcoHomes standard. The introduction starts with a compulsory share of 5% EcoHomes in 2005 followed by 10% in 2006. This rate will then increase by 10% each year until in 2015 all new homes will be EcoHomes.
- **Scenario 2c ("Eco & Zero")**: assumes a faster introduction of EcoHomes (starting with 10% share in 2005 and reaching 95% in 2010) followed by a compulsory introduction of zero fossil fuel homes (BedZED standard). The 'zero' standard will become compulsory for 5% of all newly built homes in 2010. This rate will gradually increase by 10% each year until in 2020 all new homes will be zero fossil fuel homes.

The effects of immigration policies were not modelled, i.e. no assumptions were made on regulations regarding population growth or household size.

Figure 18 shows the resulting Ecological Footprint of all new homes in global hectares of the three scenarios 2a, 2b and 2c. The sharp drop of the Ecological Footprint between 2001 and 2003 is exclusively due to the decrease in new house building in these years. Environmental regulation is assumed to take effect only from 2005 onwards, according to the assumptions in scenarios 2a-c.

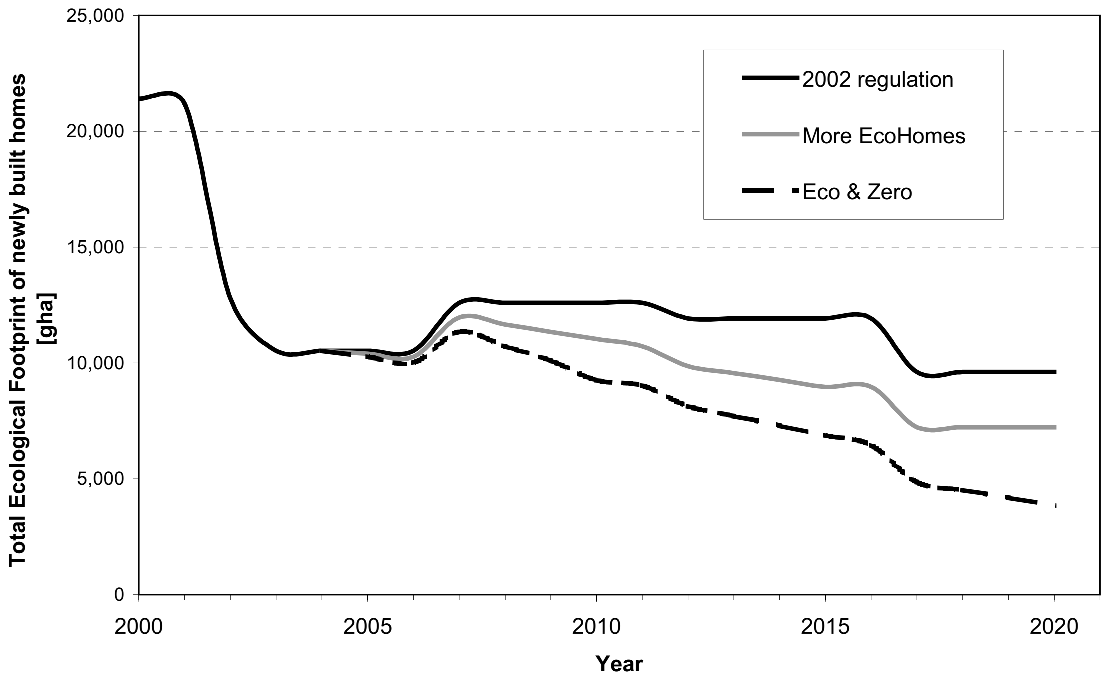

Figure 18: Total Ecological Footprint for all newly built homes in Wales for scenarios 2a, 2b and 2c

The scenarios show that the Ecological Footprint of new homes can be reduced substantially through the gradual yet compulsory introduction of EcoHome standards (minus 25% by 2020) or BedZED standards (minus 60% by 2020). However, it has to be borne in mind that this only affects *newly* built homes. Without any additional measures on the existing housing stock the respective reductions for the *total* housing stock footprint would be only -0.9% ("More EcoHomes") and -1.7% ("Eco & Zero"). Energy efficiency scenarios for the housing stock in Wales are discussed in Chapter 4 (Energy).

6.4 Conclusions

The analysis shows that the energy consumption that is associated with living in a home (heating, cooking, hot water, etc.) amounts to a higher Ecological Footprint than the materials that are needed to build the house. It also shows however, that it is much easier to reduce the energy component of the footprint.

Environmental standards like ‘BRE EcoHomes’ or zero fossil fuel ‘BedZED’ homes can be used in building regulations to reduce the energy consumption of new houses. The reduction in Ecological Footprints of new homes can be substantial (up to 60% savings in scenario 2c). However, these policies must be accompanied by measures to improve the energy efficiency of the existing housing stock in order to make a substantial difference.

New build homes with high environmental standards can also go hand in hand with an educational campaign at promoting ‘sustainable living’. People wanting to purchase such a home, will most probably already have an interest in green lifestyles and should therefore be targeted (if not interested, good opportunity to raise awareness.) Design details should be highlighted, as well as facilities provided e.g. space allocated for recycling bins, energy efficient equipment, and other programmes to encourage sustainable lifestyles e.g. car share/allotments etc.

7. Waste

7.1 Summary of Results

7.1.1 INTRODUCTION

The focus of this chapter is the domestic waste stream in Wales. It is acknowledged that the other waste streams are also of vital importance and should not be ignored when devising Welsh waste policy. However, it was thought, that for the purpose of this chapter the domestic waste stream was the most important to consider. There are two reasons for this.

Firstly and most importantly the domestic waste stream represents what has been consumed within Wales. The purpose of this study as a whole was to look at this impact of Wales, from the point of view that Wales is responsible for the impact of what its residents consume i.e. to look at the Ecological Footprint and the associated global impact of consumption. Domestic waste is a direct result of consumption and a good indicator of what is passing through a household in a typical year. To date, household waste management in Wales has had a poor record. Only 7 per cent of household waste is recycled, the average in the UK being 11 per cent, while in Austria levels often reach over 50 per cent[75]. The majority of waste is dumped in landfill sites that not only take up valuable land space but also cause pollution and discharge greenhouse gases responsible for global warming[76]. Alongside this, municipal waste continues to grow at 4 per cent per annum. The second reason for the focus on domestic waste was that the level of detail in data goes far beyond that of any other waste sector enabling a thorough and informative analysis to be conducted.

The Ecological Footprint for waste is not included in the 'standardised' Footprint calculations but is treated as a satellite account instead. The reason being that the impacts of household consumption can only be counted once, either at the 'input' side, when products are bought or consumed, or at the 'output' side, when these products are discarded. The method described above looks at the environmental pressures of consumables and therefore it would be double counting if the impact of waste from these consumables were just added on.

For specific analyses however, it is useful to look at the impacts of waste separately. For example, this allows us to explore and compare different waste management technologies. Therefore, the Ecological Footprint of waste has been calculated separately as a satellite account, i.e. the results are 'stand alone numbers' that exist in parallel to the 'standardised' Footprint and must not be added to any of the other results. An exception was made for waste recycling because some of the adverse impacts of consumption can be alleviated through the recycling of materials after their use. For more information please refer to the methodology in the Appendix or to the methodology detailed in the report of the project "Taking Stock – A Material Flow Analysis and Ecological Footprint of the South East"[77].

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[75] Waste Not Want Not, Recycling and Welsh Consumers (2002) Welsh Consumer Council

[76] Wise about Waste: the National Waste Strategy for Wales (2002) Welsh Assembly Government.

[77] available on the website www.takingstock.org in the 'Resource Pack' area

7.1.2 DATA COLLECTION

A thorough analysis was conducted to assess all existing waste data in Wales. This data has been compiled into a database and can be accessed on request. The list of data collected and the data sources can be viewed in Table 71 of the appendix at the end of this chapter.

7.1.3 CALCULATING THE MATERIAL FLOW ANALYSIS

The Material Flow Analysis was calculated using data on the tonnage of materials entering each waste stream and the associated disposal techniques. This data was derived from the aforementioned data sources and results are shown in Table 72 of the appendix.

7.1.4 CALCULATING THE ECOLOGICAL FOOTPRINT

The Ecological Footprint of waste can be divided into four categories:

- The Ecological Footprint of waste to landfill
- The Ecological Footprint of recycled and composted waste
- The Ecological Footprint of waste transportation
- The Ecological Footprint of the energy requirements of landfill processing

The methodology employed for the Ecological Footprint of waste in the study for all these categories has been given below.

The Ecological Footprint of waste to landfill

The Ecological Footprint of waste that goes to landfill considers the total energy required in producing the product that is being disposed of. The assumption is that the embodied energy of the product has not been utilised by it going to landfill, so has therefore been wasted. The Stockholm Environment Institute–York has developed an embodied energy database of over 600 products. This database has been used for this study. The embodied energy is then converted into the carbon dioxide emissions associated with the production of the product assuming the average UK energy mix.

The carbon dioxide emissions are converted into an Ecological Footprint by considering the amount of forest land that is required to absorb the carbon dioxide (assumption of 5.2 tonnes of carbon dioxide per hectare of forest land) and an equivalence factor for energy land of 1.35.

The Ecological Footprint of recycled and composted waste

The recycling footprint is the amount of energy required to recycle the product minus the energy required to produce it. The Ecological Footprint of composting is the energy required in composting the organic material. All calculations include the transportation requirements either to recycle or deliver to landfill (explained below).

The energy required to recycle is always lower than that used in producing the product from virgin materials. However, there is a large variation between products in the potential for energy savings from recycling. Aluminium cans produced from raw materials have an Ecological Footprint of 6.72 ha per tonne. The energy required to recycle aluminium cans is relatively small with an Ecological Footprint for recycled aluminium of only 0.40 ha per tonne. The Ecological Footprint for recycled aluminium cans is therefore 95 per cent less than that for aluminium cans made from virgin materials. For plastics the saving is not so favourable. PET from virgin material has an Ecological Footprint of

2.31 ha per tonne, while the recycled PET Ecological Footprint is 2.06 ha per tonne. Thus there is only an 11 per cent advantage of recycling over the use of raw materials.

The more material that is recycled the lower the Ecological Footprint will be. However, the issue of the throughput of materials is also taken into account. The higher the volume of material consumed by Welsh residents, the greater will be the resultant Ecological Footprint. The methodology employed is therefore responsive to different waste strategies. For example, the Ecological Footprint will decrease with the introduction of recycling and composting schemes, waste minimisation schemes, product substitution and incineration.

The Ecological Footprint of waste transportation

For domestic waste collected from households (bins and kerbside collection) the average distance travelled by waste collection lorries was considered. If a CO_2 emission factor for diesel of 808.6 g CO_2/km (given in UK emission factors database for rigid HGVs for the year 2000) is assumed, this equates to an Ecological Footprint of 0.0023 gha per tonne of waste (South East report). This factor was then used to determine the emissions from waste transportation.

7.1.5 MFA RESULTS

The total quantity of waste in the Welsh municipal waste stream in the year 2000 was 1.6 million tonnes[78] (See Table 56). A high proportion of this, 93% or 1.5 million tonnes ended up in landfill.

Table 56: Total municipal Waste in the Welsh waste stream 2000 (DEFRA, 2003)

Waste Management	Tonnes	Proportion of total municipal waste (%)
Landfill	1,527,989	93.0
Incineration with Energy Recovery	-	-
Incineration without Energy Recovery	240	0.015
Refuse Delivered fuel manufacture	-	-
Recycled	96,040	5.8
Composted	18,917	1.2
Other	-	-
Total	**1,642,186**	**100**

To determine the compositional breakdown of materials entering landfill sites in Wales, data on municipal waste composition released by the Welsh Assembly was applied to the total tonnes of waste entering landfill. The results are shown in Table 57.

[78] Municipal Waste Management Survey Wales 2003. (DEFRA)

Table 57: The composition of municipal waste sent to landfill in Wales 2000

	Composition (%)	Tonnes
Newspapers and magazines	8.7	132,956
Other recyclable paper	4.1	62,657
Card packaging	7.8	119,202
Other paper	5	76,411
Plastic film	3.2	48,903
Dense plastic packaging	3.2	48,903
Other dense plastic	0.8	12,226
Textiles	2.2	33,621
Other combustibles	12.1	184,916
Glass	6.2	94,750
Compostable kitchen waste	8	122,258
Garden waste	10.3	157,408
Soil and other putrescibles	10.7	163,521
Ferrous cans	1.7	25,980
Other ferrous metal	2.8	42,790
Non-ferrous metal	0.9	13,754
Waste electrical/electronic equipment	3	45,847
Potentially hazardous materials	0.5	7,641
Fines	3.7	56,544
DIY and other non-combustibles	5.1	77,940
Total	**100**	**1,528,229**

The most significant categories in terms of total tonnages being sent to landfill site are 'miscellaneous combustibles', 'soil and other putrescibles' and 'garden waste' with 185, 163.5 and 157.5 thousand tonnes of waste entering landfill sites in a one year period. However if you place all paper products into one category, they produce the largest waste component by a significant portion, totalling almost 400 thousand tonnes of waste.

Table 58: Tonnage of waste sent to landfill and recycled in Wales 2000

	Total Waste Landfilled	Waste per Capita	Waste per Household	Total waste recycled or composted	Recycled or Composted Waste per Capita	Recycled or Composted Waste per Household
	tonnes	kg/capita/ week	Kg/household/ wk	tonnes	kg/ capita/ week	kg / household / week
Paper and card	391,227	2.58	6.29	43,614	0.29	0.70
Glass	94,750	0.63	1.52	18,637	0.12	0.30
Ferrous metals	68,770	0.45	1.11	11,033	0.07	0.18
Non-ferrous metals	13,754	0.09	0.22	11,033	0.07	0.18
Dense plastic	61,129	0.40	0.98	542	0.00	0.01
Plastic film	48,903	0.32	0.79		-	-
Textiles	33,621	0.22	0.54	3,629	0.02	0.06
Miscellaneous	372,888	2.46	6.00	2,875	0.02	0.05
Putrescibles	443,186	2.93	7.13	23,595	0.16	0.38

Total	1,528,229	10.1	24.6	114,957	0.76	1.85

When looked at on a per capita basis, as shown in Table 58, the average Welsh resident produces 10 kg of waste in one week, or 525 tonnes in a one year period. For comparison the average resident recycled a total of 0.76 kg in a one week period, this being approximately 7 per cent of their total waste. The material with the highest recycling rate is paper and card. In a one year period over 43 thousand tonnes is recycled in Wales. This is 10% of all paper and card that ends up in the waste stream.

7.1.6 EF RESULTS

The total Ecological Footprint of municipal waste in Wales is 0.71gha per resident. This equates to almost 2 million gha for the entire population of Wales. As described previously this figure includes the embodied energy of the materials in the waste stream, the transportation energy needed to move the waste about and the energy needed to either treat, recycle or compost the waste when it reaches its final location. A summary table detailing the tonnages of waste in the municipal waste stream and their associated Ecological Footprints are shown in Table 59, however a more detailed table can be found in the appendix of this chapter (Table 73).

Table 59: The Ecological Footprint of the Municipal Waste stream (2000)

	Total Landfilled	Total recycled (tonnes)	Energy EF of landfilled waste	Land EF of landfilled waste	Energy EF of recycled material	EF of waste transport ation	EF of waste processing	TOTAL EF	Total EF per Capita
	tonnes/ Wales/ year	Tonnes/ Wales/ year	gha/Wales / yr	gha/Wales / yr	gha/Wales/ yr	gha/Wales / yr	gha/Wales / yr	gha/Wales/yr	gha/cap / yr
Paper and Card	391,227	43,614	220,060	782,453	21,371	898	3,340	1,028,122	0.35
Glass	94,750	18,637	18,825	-	769	217	809	20,620	0.01
Ferrous Metals	68,770	11,033	40,232	-	4,358	183	587	45,360	0.02
Non-ferrous Metals	13,754	11,033	53,131	-	3,325	57	117	56,630	0.02
Dense plastic	61,129	542	179,050	-	1,170	140	522	180,882	0.06
Plastic film	48,903	-	68,123	-	-	112	418	68,653	0.02
Textiles	33,621	3,629	69,569	202,282	5,414	85	287	277,637	0.10
Miscellaneous	372,888	2,875	154,182	-	152	862	3,183	158,380	0.05
Putrescibles	443,186	23,595	217,708	-	-	1,071	3,784	222,563	0.08
TOTAL	**1,528,229**	**114,957**	**1,020,881**	**984,735**	**36,558**	**3,627**	**13,047**	**2,058,857**	**0.71**

Of the material components in the above table, paper and card has the highest Ecological Footprint. This is partly due to the high proportion of these materials in the waste stream but also due to the fact that paper and card not only have an energy EF but also have a real land EF due to tree growth. It is also important to note that when biodegradable materials, such as paper and card, are sent to landfill they decompose and release methane gas. This gas has a much higher global warming potential than carbon dioxide. In these calculations however, the impact of methane gas has been omitted due to it not being included in the standardised Ecological Footprint (refer to the Appendix). If it was to be included then the impact would be much greater.

7.2 Policy Implications

7.2.1 WELSH POLICY CONTEXT

There is pressure to curb current rising trends in waste production across Wales. The European Union (EU) has a long established Waste Framework Directive (75/442/EEC). This is further supported by more recent directives that address specific waste streams, the main drivers being: Packaging and Packaging Waste Directive (94/62/EC), Landfill Directive (1999/31/EC), and the Waste Electrical and Electronic Equipment Directive (2002/96/EC). These directives reflect the EU's approach to waste management, which is based on three principles: waste prevention, recycling and reuse, and improving final disposal and monitoring. The aim is to reduce the quantity of waste going to 'final disposal' by 20% from 2000 to 2010, and by 50% by 2050. Current UK waste legislation takes this into account.

Waste policy in Wales was devolved to the National Assembly for Wales and by 2002 the WAG responded to this pressure by replacing the joint England and Wales 'Waste Strategy 2000' with 'Wise about Waste: the National Waste Strategy for Wales'. This new strategy establishes a programme of change for the next ten years, aiming to correct the current state of waste management in Wales. The waste strategy also links strongly, and is consistent, with the WAG's overarching sustainable development scheme presented in Wales: A Better Country (2003).

7.2.2 KEY POLICY OBJECTIVES & TARGETS

The National Waste Strategy for Wales sets clear targets which encompass the EU's waste management principles: **UK** targets where Wales must meet targets set for the UK in EU Directives, **primary** Wales specific targets where the Assembly Government and its key partners (e.g. local government) have a direct influence over their outcome and **secondary** Wales specific targets where the Assembly Government's influence is less (see Table 60).

Table 60: Key Policy Objectives and Targets for Waste Management in Wales

The **UK** targets are:

Targets to limit the amount of biodegradable municipal waste (BMW) landfilled:

- by 2010 no more than 75% of the BMW produced in 1995 can be landfilled;
- by 2013 no more than 50% of the BMW produced in 1995 can be landfilled;
- by 2020 no more than 35% of the BMW produced in 1995 can be landfilled.

The 2002 targets for companies obligated under the Packaging Regulations:

- recover 59% of packaging waste;
- recycle at least 19% of each material.

The End of Life Vehicles (ELV) Directive targets:

- no later than 1st January 2006, for all ELV, re-use and recovery shall be increased to a minimum of 85% by an

average weight per vehicle and year. Within the same time limit the re-use and recycling shall be increased to a minimum of 80% by an average weight per vehicle and year; • no later than 1st January 2015, for all ELV, the re-use and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Within the same time limit, the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year.
The **primary** Wales specific targets are: Public bodies to reduce their own waste arisings: • by 2005, achieve a reduction in waste produced equivalent to at least 5% of the 1998 arisings figure; • by 2010, achieve a reduction in waste produced equivalent to at least 10% of the 1998 arisings figure. Minimum recycling and composting targets for each local authority to deliver: • by 2003/04 achieve **at least** 15% recycling/composting of municipal waste with a minimum of 5% composting (with only compost derived from source segregated materials counting) and 5% recycling; • by 2006/07 achieve **at least** 25% recycling/composting of municipal waste with a minimum of 10% composting (with only compost derived from source segregated materials counting) and 10% recycling; • by 2009/10 and beyond achieve **at least** 40% recycling/composting with a minimum of 15% composting (with only compost derived from source segregated materials counting) and 15% recycling. Improved segregation of hazardous household waste: • by 2003/04 all civic amenity sites should have facilities to receive and store, prior to proper disposal, bonded asbestos sheets. All sites should also have facilities for receiving and storing, prior to recycling, oils, paints, solvents and fluorescent light bulbs.
The **secondary** Wales specific targets are: Stabilisation and reduction of household waste: • by 2009/10 waste arisings per household should be no greater than those (for Wales) in 1997/98; • by 2020 waste arisings per person should be less than 300kg per annum. The Assembly Government encourages businesses to join in with the public sector to meet, and exceed where possible, the following waste minimisation targets: • by 2005, achieve a reduction in waste produced equivalent to at least 5% of the 1998 arisings figure; • by 2010, achieve a reduction in waste produced equivalent to at least 10% of the 1998 arisings figure. To divert waste from landfill: • by 2005, to reduce the amount of industrial and commercial waste sent to landfill to less than 85% of that landfilled in 1998; • by 2010, to reduce the amount of industrial and commercial waste going to landfill to less than 80% of that landfilled in 1998. To reduce hazardous waste: • by 2010, to reduce the amount of hazardous waste generated by at least 20% compared with 2000. To divert biodegradable waste from landfill: • by 2005, to reduce the amount of biodegradable industrial and commercial waste sent to landfill to 85% of that landfilled in 1998; • by 2010, to reduce the amount of biodegradable industrial and commercial waste going to landfill to 80% of that landfilled in 1998. To re-use and recycle construction and demolition waste:

- by 2005, to re-use or recycle at least 75% of C&D waste produced;
- by 2010, to re-use or recycle at least 85% of C&D waste produced.

7.2.3 EF IMPLICATIONS

The key targets, instruments and actions set out to deliver the policies in 'Wise about Waste: the National Waste Strategy for Wales' look set to bring about changes to the current waste management system. These changes will have subsequent impacts on the current Ecological Footprint of waste. While it is safe to assume that a reduction in waste produced will reduce the overall waste Footprint, it is necessary to conduct a detailed analysis to ascertain the precise extent of the reduction, taking into account factors that may distort the final impact. In the following section, five of the twelve waste targets listed in Table 60 above have been explored. Lack of sufficient reliable data has limited the analysis to only five scenarios. The results generated provide a useful and interesting insight into the potential strength the policies have at placing waste management in Wales on the right footing.

7.3 Future Scenarios

The scenarios presented attempt to identify where the most significant reductions can be achieved in terms of their Ecological Footprint. It is not possible to add the reductions achieved in the different scenarios together, as double counting would be involved. Each scenario must be viewed in isolation.

7.3.1 REDUCTION OF WASTE PRODUCED BY THE PUBLIC AND BUSINESS SECTOR

In the National Waste Strategy for Wales the Welsh Assembly have stated that they are launching a public sector waste minimisation campaign and that they are going to provide support so that businesses can manage their waste more sustainably.

This Waste minimisation campaign also makes a focus on Hazardous waste however for the following reasons the Ecological Footprint of reducing this waste stream has not been calculated. It is felt that the Ecological Footprint is not a suitable indicator to measure the impact of hazardous waste, as it does not inform us about the damaging environmental impacts of this waste stream. Secondly, even if we were to calculate the Footprint then it would only be a rough estimate as the exact composition of hazardous waste is unknown, making it very difficult to determine its embodied energy.

Policy targets set by the WAG

- ‘By 2005, achieve a reduction in waste produced equivalent to at least 5% of the 1998 arisings figure,
- ‘By 2010, achieve a reduction in waste produced equivalent to at least 10% of the 1998 arisings figure’

The Welsh public and business sector produced a total of 1,141 thousand tonnes of waste in the year 1999 (Environment Agency). This baseline figure was taken and used to predict the volume of waste the policy targets are aiming to achieve in 2005 and 2010. It was assumed that the composition of waste would remain constant between 1998 and 2010. Once estimations had been derived the associated Ecological Footprints were calculated.

Results

Table 61: Potential Ecological Footprint reductions through the reduction of public and business sector waste

Year	EF (gha)	Percentage reduction
1998	2,019,348	-
2005	1,918,381	5%
2010	1,817,413	10%

Table 61 shows that if the public and business sector produce less waste there will be an associated decrease in the Ecological Footprint. The Welsh waste policy states that there will be support for businesses in the reduction of waste production. It states that 'Businesses should grasp opportunities to take the lead in innovative approaches to sustainable waste management to put Wales at the forefront in the provision of technologies and services'. However for this to happen there needs to be either an incentive to decrease waste or disincentive for it to increase any further. In response to this the Welsh Waste Strategy suggests that a range of current instruments and initiatives will be used to deliver resource productivity. For example tax incentives and taxes on waste management practices. Such mechanisms can act as a driving force to induce change, as it is likely only to occur when it favours the business economically to do so.

7.3.2 STABILISATION AND REDUCTION OF HOUSEHOLD WASTE

Curbing growth and reducing waste are both highly important policy initiatives as not only do they make important and direct contributions to sustainable waste management, help prevent environmental deterioration and resource depletion but also helps to reduce waste management costs. However such policy targets are far easier set than achieved. The main issue that arises when considering household waste reduction is that many of the factors controlling the amount of waste discarded by individuals is largely beyond the control of individual local authorities or the Welsh Assembly. The only real opportunity at present to take action towards implementing such a policy target is though the use of persuasive techniques. Educating the public about the consequences of producing large volumes of waste may stimulate a portion of the population to take action on moral grounds.

Policy target as set by WAG

- 'By 2020 waste arisings per person should be less than 300 kg per annum'

At present the average Welsh resident produces 464kg of waste every year. This demonstrates the ambitious nature of this policy target where it is suggested that household waste should be reduced by approximately 35% to 300 kg per capita per year.

In this scenario the total Ecological Footprint of household waste has been calculated. It is important to remember that the population of Wales is increasing and this needs to be taken into consideration too. In 2020 the population of Wales is estimated to reach 3,032,000[79] and hence if this 300kg per capita target is to be met Wales will be producing over 900,000 tonnes of waste a year.

For modelling purposes it was assumed that the same proportions existed between waste landfilled and recycled in 2020 as do at present. It was estimated that if this 300 kg per capita target is reached then on average 19kg will be recycled and 281 kg will end up in Landfill.

[79] http://www.gad.gov.uk/Population/index.asp

Results

Table 62: Potential Ecological Footprint reductions if waste reduction target is met.

Year	Total EF gha / Wales / yr	EF per resident gha / cap / yr	Reduction %
2001	1,722,201	0.59	-
2020	1,089,880	0.37	37%

The results presented in Table 62 show that a waste reduction strategy is a highly effective method of reducing the Ecological Footprint.

This target is seen as being a very important method of reducing Wales environmental impact, however to make such a reduction WAG will have to take radical action. In the National Waste Strategy for Wales the Assembly Government commit to providing substantial funding (some £68.5 million pounds between 2001-2005) to assist local authorities and others to meet targets for minimising waste, recycling and composting and limiting landfill. It is important to highlight that the most effective way to reduce waste production is to reduce household consumption, and when tackling such issues those of sustainable consumption should not be ignored but are paramount to the success of such a target. This issue has been discussed in Chapter 8. In terms of the Ecological Footprint, the waste represents a small reduction of the total environmental burden of household consumption. This is estimated at 13 per cent.

7.3.3 MUNICIPAL WASTE

Municipal Waste consists of everyday items such as product packaging, grass cuttings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries.

Policy targets

- ‘By 2003/04 achieve at least 15% recycling/composting of municipal waste with a minimum of 5% recycling’
- ‘By 2006/07 achieve at least 25% recycling/composting of municipal waste with a minimum of 10% recycling’
- ‘By 2009/10 achieve at least 40% recycling/composting of municipal waste with a minimum of 15% recycling’

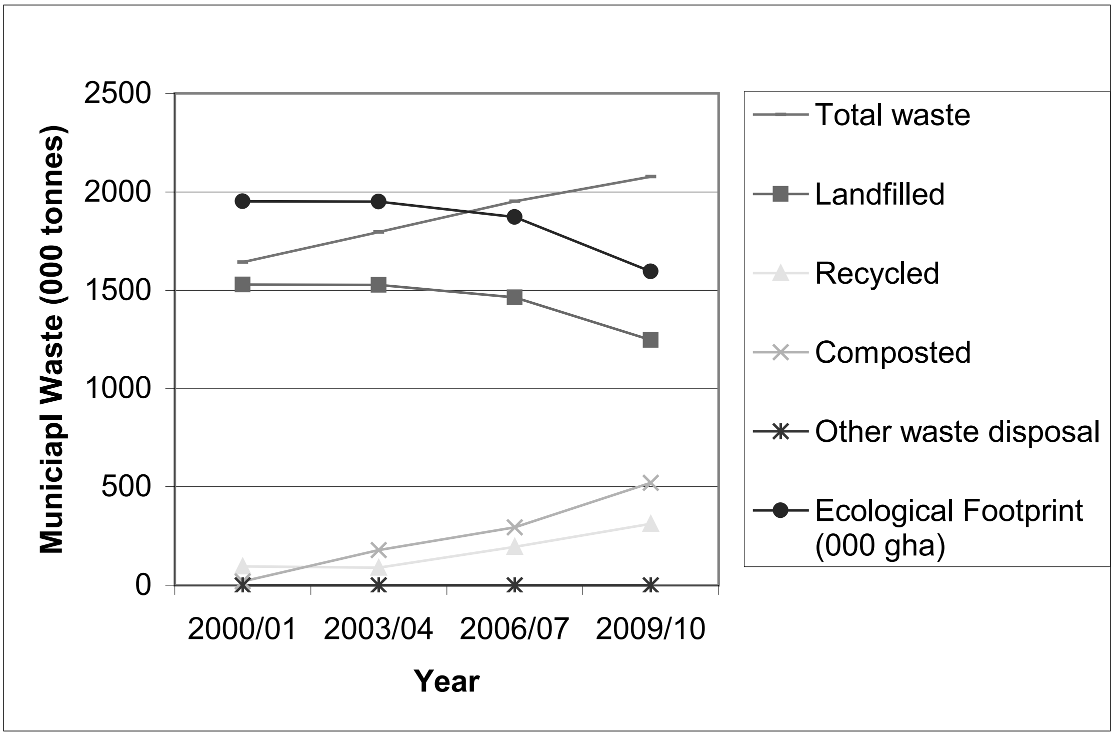
When calculating this scenario it was important to also take into consideration the impacts of waste growth. The three Welsh regional waste plans released in the past year have all provided data on estimated municipal waste growth over the next 20 years. This data was used to develop an estimation of overall municipal waste growth in Wales. It was estimated that from its 2001 level, municipal waste would have increased 9% by 2004, 19% by 2007 and 27% by 2010. Its important to consider this increase as it simultaneously increases the total volume of waste that needs to be recycled or composted to meet the targets. The data used and Ecological Footprint results are shown in Table 63 and Figure 19.
Figure 19

Results

Table 63: Results of the municipal waste recycling scenario

Waste Type	Unit	2000/01	2003/04	2006/07	2009/10
Total waste	tonnes	1,642,186	1,796,130	1,952,150	2,077,641
Landfilled	tonnes	1,527,989	1,526,448	1,463,827	1,246,281
Recycled	tonnes	96,040	89,806	195,215	311,646
Composted	tonnes	18,917	179,613	292,822	519,410
Other waste disposal	tonnes	240	262	285	304
Ecological Footprint	gha/Wales/yr	1,951,794	1,951,472	1,872,220	1,595,325
Ecological Footprint per capita[80]	gha/cap/yr	0.67	0.67	0.63	0.54
Reduction in EF	%	-	0.6%	5.8%	20%

Figure 19: Trends of municipal waste streams and the Ecological Footprint according to the recycling/composting scenario



The Footprint is being reduced by 20 per cent through this policy initiative, a significant reduction. However as already mentioned, environmentally the more effective approach to minimise impact is to concentrate on waste reduction and both targets should be focused on in unison.

Recycling has a wide range of environmental benefits. Not only does it reduce the demand for raw materials preserving natural resources and habitats but also reduces overall energy use and association carbon dioxide emissions hence reducing the Ecological Footprint. However, it is also important to

[80] Population projections have been taken from http://www.gad.gov.uk/Population/2002/wales/wwal025y.xls (governmental statistics)

remember that Wales is only truly recycling if they actually commit to buying recycled products. For recycling to be economically viable and recycling schemes to be successful there must be markets where collectors can sell their materials. In other words ‘closing the loop’ as an item is not recycled until it is being used again. In Wales the Welsh Assembly Government have addressed this issue and their solutions are detailed as follows.

What the WAG proposes to do to overcome these issues[81]

“Resource productivity broadly means making the best use of resources without harming the environment and reducing and recycling waste are key elements. The Assembly Government will seek to improve resource productivity in Wales.”

“WAG is funding initiatives to establish sustainable markets for recyclate and composted. This contributes funding to the UK Waste and Resources Action Programme (WRAP) and to the “Creating Wales markets for Recyclate” (CWMRe) project being led by the Wales Environment Trust. It will ensure that procurement by the public sector plays its part in creating sustainable markets which encourage recycling and composting.”

7.3.4 END OF LIFE VEHICLES

If both economic and some practical issues are disregarded, almost 100% of a car can be recycled. However in practice the impact of economic factors combined with the availability of suitable recycling methods prevents this possibility from being reached. Some 93,499 cars were disposed of in Wales in 2001[82]. The average weight of a car including all its constituent materials has been estimated to be 1,113 kg[83].

Data from the Welsh strategic waste management assessment (EA, 2001) suggests that on average 64 per cent of the materials from an end of life vehicle (ELV) are recycled and 10 per cent are reused for ELV in Wales. This information has been applied to estimate the quantity and composition of materials from ELV’s in Wales and their associated disposal methods. The data for 2001 can be seen in Table 64. No data was available to determine the composition of materials directly reused from ELV’s so it was assumed that this originated from the other materials category and then was proportionally distributed amongst the remaining categories.

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[81] National Waste Strategy for Wales (WAG)

[82] SE Wales regional waste plan

[83] SE MFA study

Table 64: Materials and their disposal methods originating from ELV's in Wales 2001

	Total Waste tonnes	Landfill tonnes	Reused tonnes	Recycled tonnes
Galvanised sheet steel	17,484	441	71	17,044
Cold rolled coil steel	14,679	370	60	14,310
Hot rolled coil steel	10,472	264	43	10,208
Heavy plate steel	280	7	1	273
Alloy steel	16,643	419	68	16,224
Wire rod	654	16	3	638
Cast iron	1,776	45	7	1,732
Cast aluminium	8,882	6,938	1,125	1,945
Wrought aluminium	3,179	2,483	403	696
Copper	1,309	1,022	166	287
PE	561	556	90	5
PP	3,833	3,798	616	35
PVC	1,589	1,575	255	15
Other thermoplastics	4,207	4,207	682	0
Thermosets	1,776	1,776	288	0
Synthetic rubber	5,142	5,142	834	0
Glass	3,085	2,947	478	138
Other material	8,508	-	5,470	3,038
Total	**104,064**	**26,817**	**10,661**	**66,587**

At present the data shows that ferrous metals are already being recycled at over 90% and therefore there will be little room to increase this level of recycling further. Plastics, on the other hand are being recycled at very low levels. This is due to the fact that plastics are often found in difficult to sort mixtures and contaminated with other materials, making them complex and economically unviable to be a suitable material for recycling.

The policy targets set with regards to ELV's are to

- 'no later that 1st January 2006, for all ELV, re-use and recovery shall be increased to a minimum of 85% by an average weight per vehicle per year. Within the same time limit the re-use and recycling shall be increased to a minimum of 80% by an average weight per vehicle per year.'
- 'no later that 1st January 2015, for all ELV, re-use and recovery shall be increased to a minimum of 95% by an average weight per vehicle per year. Within the same time limit the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle per year.'

The estimated Ecological Footprint of ELV was calculated for 2001, 2006 and for 2015. It was important to also take into consideration the projected increase in the number of ELV's for these years.

Results

Table 65: Results of the End-of-Life Vehicle scenario

	2001	2006	2015
Number of ELV	93,499	93,926	110,468
Tonnes	104,064	104,540	122,951
Tonnes recycled	66,587	72,090	90,080
Tonnes Reused	10,661	11,542	14,423
Tonnes Landfilled	26,817	20,908	18,443
Total EF (gha)	**75,641**	**66,146**	**68,769**
Reduction	-	13%	9%

Table 65 shows that if the 2006 WAG targets are met there will be a reduction in the Footprint. However by 2015 the predicted increase in car purchases and their associated disposal has increased to the point that even if the targets are met the Footprint has grown from its 2006 level. An increase in consumption has outpaced the increase in efficiency of disposal.

7.3.5 THE SUSTAINABLE MANAGEMENT OF BIODEGRADABLE WASTE

The decomposition of biodegradable waste leads to the release of high levels of methane, a powerful greenhouse gas. Due to the recent standardisation of the Ecological Footprint methodology methane emissions are no longer considered in the final footprint calculations. However due to the fact that it has a global warming potential 21 times that of carbon dioxide[84] and its prominence in the WAG waste strategy it was considered as an important policy to assess.

Policy:

- 'A target limiting the amount of biodegradable municipal waste (BMW) landfilled by each local authority in any given year. The targets for Wales
    - by 2010 no more than 0.675 million tonnes of BMW can be landfilled
    - by 2013 no more than 0.45 million tonnes of BMW can be landfilled.
    - by 2020 no more than 0.315 million tonnes of BMW can be landfilled.'

It is important to note that this target is intrinsically liked to the recycling/composting targets that have also been derived by the WAG. For this reason any reduction in the Ecological Footprint can not be added to a reduction made from the recycling/composting scenario as this would resulting double counting. It was however deemed important to assess this policy due to its link with methane emissions as well as to look into the different management options of biodegradable waste.

The total volume of biodegradable municipal waste was estimated for 2010, 2013 and 2020 under both a low growth and high growth scenario (1% and 3% growth respectively). This was estimated from a figure of 1.038 million tonnes of biodegradable waste in 2000 and applied to the percentage material composition[85]. The estimated tonnages of each material type are shown in Table 66.

[84] Natural Resources Canada (2003) http://www.canren.gc.ca/tech_appl/index.asp?CaId=2&PgId=1150

[85] Strategic Waste management Assessment for Wales, Environment Agency.

Table 66: Projected growth of Biodegradable waste under low and high growth scenarios.

	Biodegradable waste %	2010 low tonnes	2010 high tonnes	2013 low tonnes	2013 high tonnes	2020 low tonnes	2020 high tonnes
Newspapers & magazines	8.7	155,939	189,720	160,664	207,312	172,253	254,967
Other recyclable paper	4.1	73,488	89,408	75,715	97,699	81,177	120,157
Card packaging	7.8	139,807	170,093	144,043	185,866	154,434	228,592
Other paper	5	89,620	109,034	92,336	119,145	98,996	146,533
Plastic film	-	-	-	-	-	-	-
Dense plastic packaging	-	-	-	-	-	-	-
Other dense Plastic	-	-	-	-	-	-	-
Textiles	1.1	19,716	23,988	20,314	26,212	21,779	32,237
Other combustibles	6.05	108,440	131,932	111,726	144,165	119,785	177,305
Glass	0	-	-	-	-	-	-
Compostable kitchen waste	8	143,392	174,455	147,737	190,632	158,394	234,453
Garden waste	10.3	184,617	224,611	190,211	245,438	203,932	301,858
Soil and other putrescibles	10.7	191,787	233,333	197,598	254,970	211,852	313,581
Ferrous cans	0	-	-	-	-	-	-
Other ferrous metal	0	-	-	-	-	-	-
Non-ferrous metal	0	-	-	-	-	-	-
WEEE	0	-	-	-	-	-	-
Potentially hazardous	0	-	-	-	-	-	-
Fines	2.22	39,791	48,411	40,997	52,900	43,954	65,061
DIY and other non-combustible	0	-	-	-	-	-	-
TOTAL	**64%**	**1,146,598**	**1,394,985**	**1,181,341**	**1,524,338**	**1,266,557**	**1,874,743**

Under the high growth scenario it is estimated that by 2020 the volume of biodegradable municipal waste will have reached a volume of almost 1.9 million tonnes. If the targets are to be met then by 2020 only 0.32 tonnes will enter landfill and the remainder needs to be disposed of by alternate means. The most environmentally friendly method is to recycle and compost as much of the waste as possible.

In the following section a range of different management options have been assessed.

If there was no waste management for biodegradable waste then there would be large environmental impacts as shown in Table 67. This is mainly due to the uncontrolled release of methane that is produced during the slow decay of biodegradables in landfills. Calculations are based on the assumption that 77% of the degradable organic carbon (DOC) is dissimilated, i.e. converted to landfill gas and that the mass fraction of methane in landfill gas is 50%.

Table 67: The environmental consequences of not dealing with biodegradable waste

	Unit	2000	2010 low	2010 high	2013 low	2013 high	2020 low	2020 high
Total EF	gha/Wales/year	721,576	797,069	969,737	821,221	1,059,658	880,460	1,303,246
EF per resident	gha/cap/yr	0.24	0.27	0.33	0.28	0.35	0.29	0.43
% Change vs.baseline	%	-	10%	34%	13%	46%	19%	43%
Total Carbon	tonnes	99,613	110,034	133,871	113,368	146,285	121,546	179,911
Total Methane	tonnes	132,817	146,712	178,495	151,158	195,046	162,062	239,882
Global Warming Potential	tonnes CO_2 equiv	2,789,154	3,080,961	3,748,389	3,174,317	4,095,966	3,403,298	5,037,522

If 50% of methane is recovered there is significant reduction in all environmental impacts.

Table 68: A 50% methane recovery

	Unit	2000	2010 low	2010 high	2013 low	2013 high	2020 low	2020 high
Total EF	gha/Wales/year	360,788	398,534	484,869	410,610	529,829	440,230	651,623
EF per resident	gha/cap/yr	0.12	0.13	0.16	0.14	0.18	0.15	0.21
% Change vs. baseline	%	-	10	34	13	46	19	77
Total Carbon	tonnes	49,806	55,017	66,936	56,684	73,142	60,773	89,956
Total Methane	tonnes	66,408	73,356	89,247	75,579	97,523	81,031	119,941
Global Warming Potential	tonnes CO_2 equiv	1,394,577	1,540,480	1,874,195	1,587,159	2,047,983	1,701,649	2,518,761

Table 69 highlights the overall potential for recycling and composting. In this scenario it was assumed that all waste that can be recycled or composted was dealt with in this manner. The remainder was sent to landfill with a methane recovery rate of 50%.

Table 69: Overall Potential for Recycling and Composting

		2010 low	2010 high	2013 low	2013 high	2020 low	2020 high
Total Waste to Landfill	Tonnes	340,018	413,676	350,321	452,035	375,591	555,946
Total EF	gha / Wales/ year	91,912	111,823	94,697	122,192	101,528	150,281
EF per Capita	gha / cap/yr	0.03	0.04	0.03	0.04	0.03	0.05
Total Carbon	Tonnes	12,688	15,437	13,073	16,869	14,016	20,746
Total Methane	Tonnes	16,918	20,583	17,430	22,491	18,688	27,662
Global Warming Potential	tonnes CO_2 equiv	355,275	432,238	366,040	472,318	392,444	580,892
CO_2 release if waste is incinerated	tonnes CO_2 equiv	46,524	56,603	47,934	61,851	51,392	76,069

Under this scenario there is still a global warming potential equivalent to over half a million tonnes of carbon dioxide. After all recycling and composting has been undertaken, one method to deal with the remainder is to use the biodegradable municipal waste as an energy source. It makes sense to derive energy from the remaining waste, partly because the process would convert methane to carbon dioxide, a much less powerful green house gas. Table 69 shows that if all the remaining BMW is dealt with in this manner then the GWP is reduced to 76,000 tonnes of carbon dioxide (87% reduction).

The analysis below moves on to explore the possibilities of reaching the biological waste targets through implementation of the recycling and composting targets (by 2010 achieve at least 40% recycling and composting)

The estimated tonnage data is shown below in Table 70.

Table 70: Achieving the Biological Waste Target through recycling and composting (all values are in tonnes)

Year	MW	BMW	Non Landfilled	Inciner-ation	Compost	Recycle	Landfilled
2000 base line	1,622,636	1,038,000	46,129	-	11,975	34,154	991,871
2010 low growth	1,792,399	1,146,598	716,960	-	328,009	388,951	429,638
2010 high growth	2,180,687	1,394,985	872,275	-	399,066	473,209	522,711
2013 low growth	1,846,711	1,181,341	738,684	-	337,948	400,736	442,657
2013 high growth	2,382,895	1,524,338	1,074,338	121,180	436,070	517,088	450,000
2020 low growth	1,979,924	1,266,557	951,557	159,588	362,326	429,643	315,000
2020 high growth	2,930,660	1,874,743	1,559,743	387,479	536,311	635,953	315,000

The calculations estimated that under the low growth scenario the recycling and composting of 40 per cent BMW can enable the landfill targets to be met. Beyond this point another waste management option will be required to achieve the target.

7.4 Discussion

The most important target established by WAG is the waste minimisation target. This has the potential to bring about a significant reduction in the Ecological Footprint of the waste stream. However, it is also one of the most difficult targets to achieve. It will be impossible to achieve through the actions of WAG alone. It will need a concerted effort at the UK and Europe level, taking into account issues such as overall consumption patterns and methods of packaging. However, without it, the benefits of achieving the recycling, composting and biological waste targets will be lost.

If we do manage to see a decrease in the quantity of household waste produced, then it will result in an even greater reduction of the Ecological Footprint in the biological waste scenario, since this scenario assumes a 3% per annum growth figure for municipal waste. It is also important to remember that the efficiency gains through recycling can only be achieved once and that unless fundamental questions are considered about the way we consume, these reductions will be short lived.

In conclusion, a significant impact can be made on the Ecological Footprint if the targets can be achieved, suggesting that WAG have established reasonably ambitious targets that will begin to bring about a reduction in the Ecological Footprint.

7.5 Appendix

Table 71: Data sources for waste in Wales

Categories	Data Source	Notes
WASTE CATEGORIES		
Principal waste streams	North and South West Wales Regional Waste Plan (2002)	1998/99 local authority level data on tonnage in each waste stream
Municipal waste		
Municipal waste Total	Municipal waste management survey Wales 2003	Municipal waste in tonnes and per HH/wk for 1996/2001 Broken down into waste collection method
	Strategic waste management assessment (Wales)	amount and type by management method
Municipal waste Total 2	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Municipal waste by local authority and collection method in 1998/99
Municipal waste (Local authority level)	North and South West Wales Regional Waste Plan (2002)	Tonnage of municipal waste from each local authority
MSW Material breakdown		
Municipal waste - management methods	Municipal waste management survey Wales 2003	Municipal waste management methods for Wales 1996/2001
Municipal waste - management methods 2	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Municipal waste management at local authority level
Municipal waste landfilled	Municipal waste management survey Wales 2002	Municipal waste landfilled by its source for 1998/2001
Municipal waste growth	North and South West Wales Regional Waste Plan (2002)	percentage waste growth 1998/2001
Municipal waste recycled and composted	Municipal waste management survey Wales 2003	Municipal waste recycled and composted by method for each Local Authority 1998/2001
municipal waste recycled by material	South East Wales waste management Plan	municipal waste recycled in South Eat Wales by material (LA) 2000/01
Municipal waste records and comp targets	North and South West Wales Regional Waste Plan (2002)	Actual and potential targets for recycling and composting in each region
Biodegradable Municipal Waste and Forecasts	South East Wales waste management Plan	Municipal waste that is biodegradable and forecasts up to 2020, recycling and composting and portion sent to landfill
municipal waste forecasts	South East Wales waste management Plan	waste forecasts up to 2021 under 3 scenarios
Household waste		
Household waste recycling and composting	Municipal waste management survey Wales 2003	
Household waste records and comp composition	Municipal waste management survey Wales 2004	Breakdown of materials recycled by waste management method in 1999 and 2000
	Waste not want not, Welsh consumers council (2002)	Types of household waste regularly recycled by Welsh consumers by region
Household waste - management methods	Local authority performance indicators for Wales 1999/00	Local authority level data on the management of HH waste e.g. used to recover heat
Industrial waste		
Industrial waste Total	North and South West Wales Regional Waste Plan (2002)	Amount of waste per local authority, waste management method and waste projections for 2005
	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Sub regional total waste data
Industrial waste - waste trpe	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Industrial waste arising by business sector and waste type in Wales 1998/99
	Strategic waste management assessment (Wales)	Waste arising per welsh sub region

Categories	Data Source	Notes
Industrial waste - management method	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Industrial waste arising by waste type and waste management method in Wales 1998/99
	Strategic waste management assessment (Wales)	Waste management method used in welsh sub-regions
Industrial waste- forecasts to 2021	SE Wales waste management plan	Forecasts for SE Wales up to the year 2021
Commercial waste		
Commercial waste	North and South West Wales Regional Waste Plan (2002)	Waste arising per local authority and waste management method. Projections for 2005 2010 and 2015
	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Sub regional total waste data
Commercial waste - waste type	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Commercial waste arising by business sector and waste type in Wales 1998/99
	Strategic waste management assessment (Wales)	Waste arising per welsh sub region
Commercial waste - management method	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Commercial waste arising by waste type and waste management method in Wales 1998/99
	Strategic waste management assessment (Wales)	Waste management method used in welsh sub-regions
Commercial waste forecasts up to 2021	SE Wales waste management plan	Forecasts for SE Wales up to the year 2021
Construction and Demolition waste		
C & D waste Total	North and South West Wales Regional Waste Plan (2002)	regional waste by type of waste, for 1999 and 2001
	Environment agency [www.environment-agency.gov.uk/subjects/waste/232028/169145/176602/341920/?lang=_e]	Breakdown of all components in Wales in 1999
C & D waste - management method	North and South West Wales Regional Waste Plan (2002)	Regional waste management methods for 1999 and 2001 and targets for 2005, 2010 and 2015
C & D waste - Forecasts		Forecasts for SE up to 2021
Special waste		
Special waste Total	North and South West Wales Regional Waste Plan (2002)	Waste arising from individual industries and processes for local authority in SW Wales. North Wales data on material breakdown of special waste collected
	Waste not want not, Welsh consumers council (2002)	Total special waste produced in the Wales region broken into waste categories
Special waste - management method	North and South West Wales Regional Waste Plan (2002)	Management methods for special waste, SWW has local authority specific data NW is regional specific
Special waste movements	Waste not want not, Welsh consumers council (2002)	The movement of special waste in Wales
Special waste forecasts up to 2021	SE Wales waste management plan	Forecasts for SE Wales up to the year 2021
Agricultural waste		
Agricultural waste	North and South West and South East Wales Regional Waste Plan (2002)	Local authority specific data for a detailed breakdown of the components of agricultural waste
Agricultural waste 2	Strategic waste management assessment (Wales)	Agricultural waste and by-products in the Welsh sub regions
Agricultural waste Forecasts up to 2021	SE Wales waste management plan	Forecasts for SE Wales up to the year 2021
Other waste streams		

Categories	Data Source	Notes
Other waste - total	Strategic waste management assessment (Wales)	Other waste generated in Wales, e.g batteries and tyres
Electrical and Electronic equipment	SE Wales Regional waste plan (2002)	Waste arising and disposal method
End of Life Vehicles	SE Wales Regional waste plan (2002)	Tonnes per year in SE Wales, forecasts and the tonnage of materials per ELV
WASTE MANAGEMENT		
waste management facilities in Wales	North and South West Wales Regional Waste Plan (2002)	Local authority breakdown of waste management facilities Capacity of waste treatment facilities in each region
waste management facilities - Total	North and South West Wales Regional Waste Plan (2002)	Local authority data on total amount of waste collected by each waste management facility
Categories of waste management		
Treatment		
waste management - Treatment	North and South West Wales Regional Waste Plan (2002)	local authority data on waste deposited at open/closed treatment facilities by type of waste
Open gate		
waste management - open gate	North and South West Wales Regional Waste Plan (2002)	local authority data on waste arriving at open gate sites by type of waste
Landfill		
waste management - landfill	North and South West Wales Regional Waste Plan (2002)	local authority data on waste deposited at landfills by type of waste
remaining capacity of landfill	North and South West Wales Regional Waste Plan (2002)	local authority level data on remaining landfill capacity
Licensed capacity at landfill sites	Environment Agency [http://www.environment-agency.gov.uk/subjects/waste/232028/169145/184122/341928/?lang=_e]	Landfill capacity
Landfill site addresses	Register of landfill site operators HM customs and excise	Addresses of all registered landfill sites in Wales
Civic amenity		
waste management - civic amenity	North and South West Wales Regional Waste Plan (2002) Strategic waste management assessment (Wales)	Local authority level data on waste being taken to civic amenity sites waste handled by type of waste and sub region
Biotreatment		
Remaining capacity	SE Wales Regional waste plan (2002)	Remaining capacity of facilities in SE Wales
Recycling		
Recycling - rate	Waste not want not, Welsh consumers council (2002) SE Wales Regional waste plan (2002)	recycling and composting rates for local authorities Facilities available in SE Wales
metal recycling	SE Wales Regional waste plan (2002)	Inputs to metal recycling facilities in welsh sub regions
Physical and chemical treatment		
Capacity in SE Wales	SE Wales Regional waste plan (2002)	Capacity of facilities in SE Wales
Incineration		
Capacity in SE Wales	SE Wales Regional waste plan (2002)	Capacity of facilities in SE Wales
WASTE FORECASTING		
waste forecasts	North and South West and South East Wales Regional Waste Plan (2002)	Yearly regional waste forecasts to the year 2021 for each different waste category

Table 72: Detailed waste material flows for Wales, 2001

	Total Waste Landfilled	Waste per Capita	Waste per Household	TOTAL WASTE RECYCLED	Waste per Capita	Waste per Household
	tonnes	kg/cap/wk	kg/household/wk	tonnes	kg/cap/wk	kg/household/wk
Total	**1,528,229**			**114,957**		
Paper and card	-	-	-	-	-	-
News and Pams	132,956	0.88	2.14	-	-	-
Catalogues & Directories	-	-	-	-	-	-
Magazines	-	-	-	-	-	-
Household paper	139,069	0.92	2.24	-	-	-
Paper and Card packaging	119,202	0.79	1.92	-	-	-
Cardboard	-	-	-	-	-	-
Non-recyclable paper	-	-	-	-	-	-
Subtotal paper	**391,227**	**2.58**	**6.29**	**43,614**	**0.29**	**0.70**
Glass		-	-		-	-
Clear glass	94,750	0.63	1.52		-	-
Green glass		-	-	-	-	-
Brown glass		-	-	-	-	-
Non-recyclable glass		-	-		-	-
Subtotal glass	**94,750**	**0.63**	**1.52**	**18,637**	**0.12**	**0.30**
Ferrous		-	-		-	-
Steel drinks cans	25,980	0.17	0.42	608	0.00	0.01
Steel food cans	-	-	-	-	-	-
Batteries	-	-	-		-	-
Aerosols	-	-	-	-	-	-
Scrap metal	42,790	0.28	0.69	10,425	0.07	0.17
Subtotal ferrous	**68,770**	**0.45**	**1.11**	**11,033**	**0.07**	**0.18**
Non-Ferrous metal		-	-		-	-
Aluminium cans	13,754	0.09	0.22	608	0.00	0.01
Aluminium foil	-	-	-	-	-	-
Scrap metal	-	-	-	10,425	0.07	0.17
Subtotal non-ferrous	**13,754**	**0.09**	**0.22**	**11,033**	**0.07**	**0.18**
Dense Plastic		-	-		-	-
PET Coloured	24,452	0.16	0.39		-	-
PET Clear		-	-		-	-
HDPE Coloured	24,452	0.16	0.39		-	-
HDPE Clear		-	-		-	-
PVC		-	-		-	-
LDPE		-	-		-	-
PP		-	-		-	-
PS		-	-		-	-
Unidentified dense plastic	12,226	0.08	0.20		-	-
Subtotal dense plastic	**61,129**	**0.40**	**0.98**	**542**	**0.00**	**0.01**

	Total Waste Landfilled	Waste per Capita	Waste per Household	TOTAL WASTE RECYCLED	Waste per Capita	Waste per Household
	tonnes	kg/cap/wk	kg/household/ wk	tonnes	kg/cap/wk	kg/household/ wk
Plastic Film		-	-		-	-
Plastic film - sacks/carriers	48,903	0.32	0.79	-	-	-
Plastic film - other		-	-		-	-
Subtotal plastic film	**48,903**	**0.32**	**0.79**		**-**	**-**
Textiles		-	-		-	-
Textiles	33,621	0.22	0.54	3,629	0.02	0.06
Shoes		-	-		-	-
Subtotal textiles	**33,621**	**0.22**	**0.54**	**3,629**	**0.02**	**0.06**
Miscellaneous		-	-		-	-
Multi-layer packaging		-	-		-	-
Gabletop cartons	-	-	-	-	-	-
Drink boxes (liquid cartons)	-	-	-	-	-	-
DIY / Renovation waste	77,940	0.51	1.25		-	-
Engine oil	-	-	-		-	-
Nappies and sanitary	-	-	-	-	-	-
Animal waste	-	-	-	-	-	-
Misc jumble sale		-	-		-	-
Misc other	45,847	0.30	0.74		-	-
Clinical Waste	7,641	0.05	0.12		-	-
Non-reusable wood	-	-	-		-	-
Fines	56,544	0.37	0.91		-	-
Furniture	-	-	-		-	-
misc combustibles	184,916	1.22	2.97		-	-
misc non combustibles	-	-	-	2,875	0.02	0.05
Subtotal miscellaneous	**372,888**	**2.46**	**6.00**	**2,875**	**0.02**	**0.05**
Putrescibles		-	-		-	-
Home compostable kitchen waste	122,258	0.81	1.97		-	-
Other kitchen waste (meat, bones etc)	-	-	-		-	-
Garden waste	320,928	2.12	5.16	23,595	0.16	0.38
Subtotal putrescibles	**443,186**	**2.93**	**7.13**	**23,595**	**0.16**	**0.38**
TOTAL	**1,528,229**	**10.09**	**24.59**	**114,957**	**0.76**	**1.85**

Table 73: Detailed breakdown of Ecological Footprints for household waste in Wales, 2001

	Energy EF per tonne Landfilled	Land EF per tonne Landfilled	Energy EF per tonne RECYCLED	Total EF of Transportation	Total EF of Processing	TOTAL EF	EF per Capita
	gha/tonne waste	gha / tonne waste	gha/tonne waste	gha/Wales/yr	gha/Wales/yr	gha/Wales/yr	gha/cap/yr
Paper and card							
News and Pams	70,658	265,911	-	305	1,135	338,011	0.12
Catalogues& Directories	-	-	-	-	-	-	-
Magazines	-	-	-	-	-	-	-
Household paper	67,489	278,137	-	319	1,187	347,133	0.12
Paper, Card Packaging	81,912	238,403		274	1,018	321,607	0.11
Cardboard	-	-	-	-	-	-	-
Non-recyclable paper	-	-	-	-	-	-	-
Subtotal paper	**220,060**	**782,453**	**-**	**898**	**3,340**	**1,006,751**	**0.35**
Glass							
Clear glass	18,824		-	217	808	19,851	0.01
Green glass	-	-	-	-	-	-	-
Brown glass	-	-	-	-	-	-	-
Non-recyclable glass	-	-	-	-	-	-	-
Subtotal glass	**18,824**		**-**	**217**	**808**	**19,851**	**0.01**
Ferrous							
Steel drinks cans	15,198	-	240	61	221	15,722	0.01
Steel food cans	-	-	-	-	-	-	-
Batteries	-	-	-	-	-	-	-
Aerosols	-	-	-	-	-	-	-
Scrap metal	25,032	-	-	122	365	25,520	0.01
Subtotal ferrous	**40,23**	**-**	**240**	**183**	**587**	**41,242**	**0.01**
Non-Ferrous metal							
Aluminium cans	53,130	-	-	33	117	53,281	0.02
Aluminium foil	-	-	-	-	-	-	-
Scrap metal	-	-	-	24		24	0.00
Subtotal non-ferrous	**53,130**	**-**	**-**	**57**	**117**	**53,305**	**0.02**
Dense Plastic							
PET Coloured	137,192	-	-	56	208	137,457	0.05
PET Clear	-	-	-	-	-	-	-
HDPE Coloured	31,978	-	-	56	208	32,244	0.01
HDPE Clear	-	-	-	-	-	-	-
PVC	-	-	-	-	-	-	-
LDPE	-	-	-	-	-	-	-
PP	-	-	-	-	-	-	-
PS	-	-	-	-	-	-	-
Unidentified dense plastic	9,879	-	-	28	104	10,012	0.00

	Energy EF per tonne Landfilled	Land EF per tonne Landfilled	Energy EF per tonne RECYCLED	Total EF of Transportation	Total EF of Processing	TOTAL EF	EF per Capita
	gha/tonne waste	gha / tonne waste	gha/tonne waste	gha/Wales/yr	gha/Wales/yr	gha/Wales/yr	gha/cap/yr
Subtotal dense plastic	**179,049**	**-**	**-**	**140**	**521**	**179,712**	**0.06**
Plastic Film							
Plastic film - sacks/carriers	68,123	-	-	112	417	68,653	0.02
Plastic film - other	-	-	-	-	-	-	-
Subtotal plastic film	**68,123**	**-**	**-**	**112**	**417**	**68,653**	**0.02**
Textiles							
Textiles	-	202,281	-	85	287	202,654	0.07
Shoes	-	-	-	-	-	-	-
Subtotal textiles	**-**	**202,281**	**-**	**85**	**287**	**202,654**	**0.07**
Miscellaneous							
Multi-layer packaging	-	-	-	-	-	-	-
Gabletop cartons	-	-	-	-	-	-	-
Drink boxes (liquid cartons)							
DIY / Renovation waste	15,938	-	-	179	665	16,783	0.01
Engine oil	-	-	-	-	-	-	-
Nappies and sanitary	-	-	-	-	-	-	-
Animal waste	-	-	-	-	-	-	-
Misc jumble sale	-	-	-	-	-	-	-
Misc other	51,283	-	-	105	391	51,780	0.02
Clinical Waste	-	-	-	18	65	83	0.00
Non-reusable wood	-	-	-	-	-	-	-
Fines	-	-	-	130	482	612	0.00
Furniture	-	-	-	-	-	-	-
misc combustibles	86,961	-	-	424	1,578	88,964	0.03
misc non combustibles	-	-	151	7	-	158	0.00
Subtotal miscellaneous	**154,182**	**-**	**151**	**862**	**3,183**	**158,380**	**0.05**
Putrescibles							
Home compostable kitchen waste	217,708	-	-	281	1,043	219,033	0.08
Other kitchen waste (meat, bones etc)	-	-	-	-	-	-	-
Garden waste	-	-	-	791	2,739.878	3,530	0.00
Subtotal putrescibles	**217,708**	**-**	**-**	**1,071**	**3,783**	**222,563**	**0.08**
TOTAL	**951,311**	**984,735**	**391**	**3,627**	**13,047**	**1,953,112**	**0.67**

8. Sustainable Consumption

8.1 Sustainable consumption

This chapter provides an understanding of how consumer characteristics and consumer lifestyles might relate to consumers' environmental impacts.

8.1.1 WHAT IS SUSTAINABLE CONSUMPTION?

As with sustainable development, the term "Sustainable Consumption" has numerous definitions. Even though the concept has existed for some time, it is only recently that the idea has been given any significant attention within the UK policy arena. The development of the "Sustainable Consumption and Production" Framework by DEFRA and the documentation produced by the Sustainable Development Commission have helped give the concept greater political importance. At the same time, sustainable consumption has been viewed as an issue that should not be touched as it variably questions the economic drive for households to consume more. Moreover, changing consumption patterns appears to challenge a number of vested interests (Jackson and Michaelis, 2003[86]).

As opposed to seeing sustainable consumption as a specific term, it is more accurate to see it as an umbrella term (UNEP, 2001[87]). UNEP suggest that sustainable consumption,

"…brings together a number of key issues, such as meeting needs, enhancing quality of life, improving efficiency, minimising waste, taking a lifecycle perspective and taking into account the equity dimension, for both current and future generations, while continually reducing environmental damage and the risk to human health."

The overall aim of a sustainable consumption policy must be to bring about a more sustainable society, one that lives within the means of nature while delivering a better quality of life for all.

8.1.2 WHY IS SUSTAINABLE CONSUMPTION IMPORTANT?

Jackson and Michaelis (2003) highlight one of the problems of excessive consumption by the North is a concern for inequality and the social and political tensions that arise from it. While poor countries are limited to resources, the industrialised countries are able to take more than their fair share of the Earth's resources. The Ecological Footprint provides a stark reminder of the inequalities that exist between the North and South, where the average resident from the North has an Ecological Footprint of 7.4 gha/cap compared to 1.7 gha/cap. The vast difference in Ecological Footprint is in correlation to the quality of life achieved within the various countries.

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[86] Jackson T. and Michaelis (2003) Policies for Sustainable Consumption, Sustainable Development Commission (available at http://www.sd-commission.org.uk/news/index.php?page=get_page&article_id=PXXSKPK-DULDB81-NJKPWJT-9BJLZPJ)

[87] UNEP 2001. Consumption Opportunities: Strategies for change, United Nations Environment Programme, Paris.

The North has also been successful in shifting the burden of environmental impact onto the South by outsourcing manufacturing to the South. In a closed space with finite resources the under consumption of one party is the necessary condition for the over consumption of the other party. The consumer classes have succeeded in passing on environmental burdens to less advantaged groups. This phenomenon also exists within specific countries such as Wales, where this study demonstrates significant differences in consumption patterns between high and low income families in Wales. There are examples of "under-consumption" as well as "over consumption" within Wales. While some are struggling to provide basic needs, others have enough to satisfy all their worldly desires.

Finally, a number of indicators would suggest that we are living beyond the carrying capacity of the planet. The fact that there is accumulation of carbon in the atmosphere acts as an indicator that the absorptive capacity of the biosphere cannot cope with the excessive emissions of industrial processes. The Ecological Footprint strengthens this position highlighting that human appropriation exceeds nature's supply by 35 per cent. In other words, we would need at least a 35 per cent larger Earth to accommodate the present material flows through the economy, sustainably. There is increasing evidence, not just with the Ecological Footprint that the world may already be effectively 'full' (Goodland 1991[88], Daly, 1991[89])

8.1.3 DOES SUSTAINABLE CONSUMPTION MEAN CONSUMING LESS?

While sustainable consumption requires an overall reduction in the throughput of materials, the idea is not solely about persuading people to be happy with less. As the above definition highlights, there is considerable room for improving technology and product substitution. The work of Paul Hawken and Amory Lovins have given numerous examples of 50 to 80 per cent improvements in the efficiency of cars, building materials, lighting and paper products. However, there are also numerous examples of how improvements in technology have been outpaced by increases consumption. These negative examples have happened, while the technology gains highlighted by Lovins have yet to be realised.

The issue of sustainable consumption is not purely an environmental one. A key element of sustainable consumption is concerned with fulfilling basic needs and this concept acts as a safeguard against actual hardship. The technology/efficiency perspective, if it is to become meaningful, must be embedded on a broader sufficiency/reduction perspective. Moreover, the twin-track approach makes the transition to sustainability easier because the pressure of high efficiency of means is softened when certain levels of sufficiency in goals are socially accepted (Sachs, 1999[90]).

Herman Daly provides an insightful example of this.

'Even if a cargo on a boat is distributed efficiently, the boat will inevitably sink under too much weight, even though it may sink optimally.' (Daly, 1992 :35[91])

In conclusion, while there is a need to consider how we can achieve a high quality of life with fewer resources, the issue of sustainable consumption does not imply a future where the residents of Wales are living in hardship. Sustainable consumption is about a prosperous future that uses fewer resources[92].

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[88] Goodland R. (1991) Why Northern Income Growth is not the Solution to Southern Poverty, *Ecological Economics*, Vol.8, No.2, 85-101.

[89] Daly H. (1991) 'Towards An Environmental Macroeconomics', *Land Economics* 67, 255-259.

[90] Sachs W. (1999) *Planet Dialectics*, Zed Books, New York.

[91] Daly, H. E. (1992). *The economic growth debate: what some economists have learnt but have not.* Eds Markandya, A. & Richardson, J. Environmental economics. London. Earthscan. pp36-49.

[92] For a full debate on the issue of consumption and how it is dealt with in the policy arena is, "Policies for Sustainable Consumption" (Sustainable Development Commission)

8.2 UK Government Policy on Sustainable Consumption

At the UK level a number of key documents provide the framework of the UK Government's response to sustainable consumption and production. The UK Government's Sustainable Consumption and Production (SCP) Framework "Changing Patterns" identifies what is required to achieve economic and social gain while respecting ecological limits (DEFRA/DTI 2003). The main suggestions are:

- Decoupling economic growth and environmental degradation
- Focusing policy on the most important environmental impact associated with the use of particular resources
- Increasing the productivity of material and energy use
- More informed individual and corporate consumers

To achieve these objectives it is acknowledged that a more holistic approach is required that explores the life cycle of products and services and integrating sustainable consumption and production issues into the policy arena while stimulating innovation.

The importance of measuring and monitoring progress has not been underestimated, with the publication of the SCP Indicators Consultation Document. While addressing some of the objectives listed above there are weaknesses in the proposed indicators. A significant concern is the impact the UK has on other countries through consumption patterns. The issue of "burden shifting" has not been fully addressed. To achieve many of the objectives listed above, there is an obvious requirement for information to be produced for policy decisions to incorporate SCP concerns, businesses require relevant and understandable information concerned with improving resource productivity and information for the general public to make more informed decisions on the products they purchase.

One of the key indicators demonstrates the trend in household consumption expenditure against greenhouse gas emissions, energy and water consumption, and waste not recycled. The underlying trend is that environmental impacts rise as consumers spend more (Sustainable Development Commission, 2004). The associated Government report "Changing Patterns" (2003) acknowledges that the drivers behind the consumption / environmental impact link are far less well understood than those behind production/ environmental impact.

The recent consultation document from the UK Government on sustainable development, "Taking it On" does highlight the issue of consumption. The consultation document states,

"Assessing the environmental limits to our use of resources is complex and one of the trickier aspects of sustainability".

It is difficult find any concrete suggestions in the report to address the issue of consumption with the only suggestion being,

"To achieve all this we will all have to play a part, from government at all levels, to business and consumers."

Finally, one of the major concerns in the approach adopted by the UK Government is that very little is said about the issue of sustainable consumption, with the main policy focus revolving around the consumption of more sustainable products. In essence, this fails to address the issue that changes in our level of consumption may be a requirement if we are to achieve a more sustainable society.

8.3 What research is required to inform policy?

Sound comparative environmental assessments are required to make informed policy decisions possible, i.e. to enable integrated environmental policy to set priority actions due to environmental impacts. However, the multi-species, multi-impact nature of environmental pollution and ecosystems makes it far from simple to recognise one, or a few, criteria to which quantification can be applied in a straightforward manner.

A range of methods have been proposed to overcome this problem (or specific parts thereof). Examples (and by no means a complete list) include the application of *Critical Loads and Levels* in tackling long range air pollution, the *IPCC assessment* of global climate change (IPCC TAR), *Environmental Impact Assessment (EIA)*, *Strategic Environmental Assessment (SEA)* and the product based approach of *Life Cycle Assessment (LCA)* (e.g. Posch et al. 2001[93], James et al[94]. 2001, Geneletti D 2002[95], Therivel et al. 1992[96], Finnveden and Moberg 2004[97]).

Indicators specified at assessing *household consumption* have been developed by the Sustainable Europe Research Institute (Lorek and Spangenberg 2001[98]). The Centre for Energy and Environmental Studies (IVEM) at Groningen University developed the *Energy Analysis Programme (EAP),* a computer programme for the calculation of the direct and indirect energy requirements and the corresponding CO_2 emissions of household consumption items (Benders et al 2001[99]).

Other concepts focus on the application side and try to provide decision support through information that is highly aggregated but easy to understand. Examples for this kind of approach include *Environmental Indicators*, the concept of *Environmental Space* or the *Ecological Footprint* (e.g. EEA 2000[100], OECD 2001[101], Moffatt 1996[102], Wackernagel and Rees 1996[103]).

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93 Posch M, PAM de Smet, J-P Hettelingh, RJ Downing (eds) (2001) Modelling and Mapping of Critical Thresholds in Europe. Status Report 2001, RIVM-Coordination Center for Effects

94 James J. McCarthy, Osvaldo F. Canziani, Neil A. Leary, David J. Dokken and Kasey S. White (Eds.) (2001) Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, UK

95 Geneletti D (2002) Ecological Evaluation for Environmental Impact Assessment; Netherlands Geographical Studies, Utrecht

96 Therivel R, Wilson E, Thomson S, Heaney D, Pritchard D (1992) Strategic environmental assessment; Earthscan, London

97 Finnveden, G., Nilsson, M., Johansson, J., Persson, Å., Moberg, Å. and Carlsson, T. (2003b): Strategic Environmental Assessment Methodologies – Applications within the energy sector. Environmental Impact Assessment Review, 23, 91-123.

98 Lorek S, Spangenberg JH (2001) Indicators for environmentally sustainable household consumption. Int. J. Sustainable Development, Vol.4, No.1

99 Benders, R.M.J., Wilting, H.C., Kramer K.J. and Moll, H.C. (2001). Description and application of the EAP computer program for calculating life-cycle energy use and greenhouse gas emissions of household consumption items. International Journal of Environment and Pollution, Vol. 15 (2), pp. 171-182.

100 EEA (2000) Environmental Signals 2000. European Environment Agency Regular Indicator Report. European Environment Agency, Copenhagen

101 OECD (2001) Environmental Indicators - Towards Sustainable Development 2001, Organisation for Economic Co-operation and Development, Paris

102 Moffatt, I., (1996). An evaluation of environmental space as the basis for sustainable Europe. Int. J. Sustainable Dev. World Ecol. 3, 49–69.

103 Wackernagel M. and Rees W. (1996) Our Ecological Footprint, New Society Publications, CA.

The Stockholm Environment Institute at York uses *Material Flow Analysis (MFA)* and *Ecological Footprints (EF)* to assess environmental impacts associated with consumption[104]. Previous work has focused on calculating consumption and its associated material flow and footprint using regional boundaries, for example studying a country, region within a country or – as has been done in the UK – a local authority area. One noticeable consequence of using such regional boundaries has been an array of footprint results that differ by only a very narrow margin. Even if a study area contains people living very different lifestyles with individual consumption patterns and varied environmental impacts, these differing levels of consumption will be evened out in the results, consequently deriving very similar results for different populations within a given country. Therefore, it has been suggested to measure the consumption of different socio-economic groups directly, i.e. patterns of high and low levels of consumption, to determine the extent to which the environmental impacts of individuals lifestyle choices differ from one another (Birch et al. 2004[105]). In this way different consumer habits can be disaggregated giving a detailed and informative picture of environmental impact within a given region.

The results below rely on a method that has incorporated economic input-output tables, Ecological Footprints, household expenditure and ACORN data. To our knowledge the results provide the most detailed assessment in the UK of the environmental impact of socio-economic groups. The detailed methodology can be found in Chapter 2.

The following results help to:

- Gain a deeper understanding of the relationship between consumer expenditure and environmental impact
- Provide a better understanding of the environmental impacts of different consumer lifestyles and socio-economic groups
- Provide a sound empirical basis to understand the huge range of influences on mainstream consumer behaviour

8.3.1 METHODOLOGY

The ACORN groups have been divided into 17 groups. It is possible to display the results in 54 ACORN groups, however it was decided that 17 groups would be adequate.

In each graph the results for all 17 groups are shown. An index of the groups is shown in Table 74 and will need to be cross-referenced with the graphs.

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[104] See www.regionalsustainability.org

[105] Birch R, Barrett J, Wiedmann T (2004) "Exploring the consumption and related environmental impacts of socio-economic groups within the UK", International Workshop on Sustainable Consumption, School of the Environment, University of Leeds, 5/6 March 2004. http://www.env.leeds.ac.uk/~hubacek/leeds04/call.htm

Table 74: ACORN group details

ACORN Number	Group Description	ACORN Number	Group Description
1	Wealthy Achievers, Suburban Areas	10	Skilled workers, home owning areas
2	Affluent Greys, Rural Communities	11	New Home Owners, Mature Communities
3	Prosperous Pensioners, Retirement Areas	12	White collar workers, better off multi-ethnic areas
4	Affluent Executives, Family Areas	13	Older people, less prosperous areas
5	Well-off workers, family areas	14	Council Estate Residents, Better-off homes
6	Affluent Urbanites, Town and City Areas	15	Council estate residents, high unemployment
7	Prosperous Professionals, Metropolitan areas	16	Council estate residents, greatest hardship
8	Better-off executive, inner city areas	17	Multi-Ethnic, low income areas
9	Comfortable middle agers, mature home owning areas		

All 17 ACORN groups are explored in six parts, each reflecting the different components of a modern lifestyle. These being:

- Food and Drink
- Consumables
- House and Energy
- Holidays
- Travel
- Services

All the results were calibrated to the Family Spending Survey that publishes Wales specific data.

8.3.2 FOOD AND DRINK

The average person in Wales spends over £20 a week on food bought and eaten at home. A further £12 per week is spent on eating out (takeaway and restaurants). Together, this accounts for 20 per cent of expenditure. However, a closer examination shows percentage of expenditure on food varying greatly across the different socio-economic groups. While the “prosperous professionals” total expenditure is considerably higher than the “council residents – high unemployment”, only 20 per cent of their total expenditure is on food compared to nearly 30 per cent.

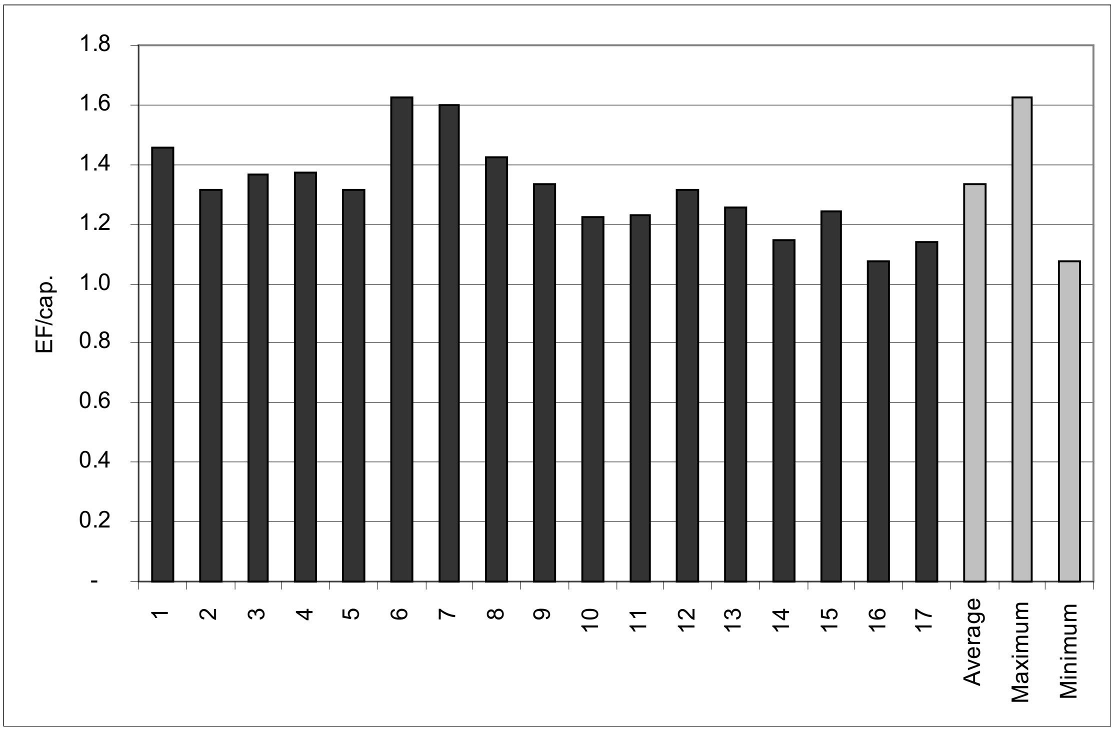

Figure 20: Ecological Footprint of Food Consumption by different ACORN Groups

One of the first conclusions to draw from the results is the fact that the variation between ACORN groups for “Food and Drink” is small in comparison to the other components. This is not too surprising as food can definitely be seen as an essential item. The other components differ greatly as many of them can be classified as luxury or “non-essential” items. The largest variation exists between Group 16 and 6; this being 32 per cent. The variation between the groups can be explained by the purchase of luxury food products. For example, Groups 6, 7 and 8 purchase a considerable amount of wine. In fact Group 8 is 66 per cent more likely to purchase wine than the national average. There is a clear link between the purchasing of luxury food items and the Ecological Footprint. At the same time, there is a required Ecological Footprint to provide the “baseline” necessary for basic nutrition.

A factor which also affects the Ecological Footprint of food is eating out at restaurants. Chapter 3 highlighted the reduced efficiency of eating in restaurants compared to eating at home. Again distinct groups in society use these services and have been allocated the associated environmental impact. Group 8 eat out at restaurants considerably more, with eating in restaurants contributing to half of their Ecological Footprint for food. A distinct contrast exists between these groups and group 16 and 17, where less than 30 per cent of their Ecological Footprint is from eating out.

Interesting Findings

- The lowest Ecological Footprint for food is 1.07 gha/cap with the highest being 1.67 gha./cap.
- The largest variation between the ACORN groups is 34 per cent.
- There is no evidence to suggest that higher income ACORN groups have a lower Ecological Footprint for food.

8.3.3 CONSUMABLES

Consumables include a range of products such as newspapers, clothing, furniture and electrical and electronic appliances. While there are considerable differences in the consumables purchased by different ACORN groups the overall variation in the Ecological Footprint is not as substantial as the other components considered (travel and holidays for example).

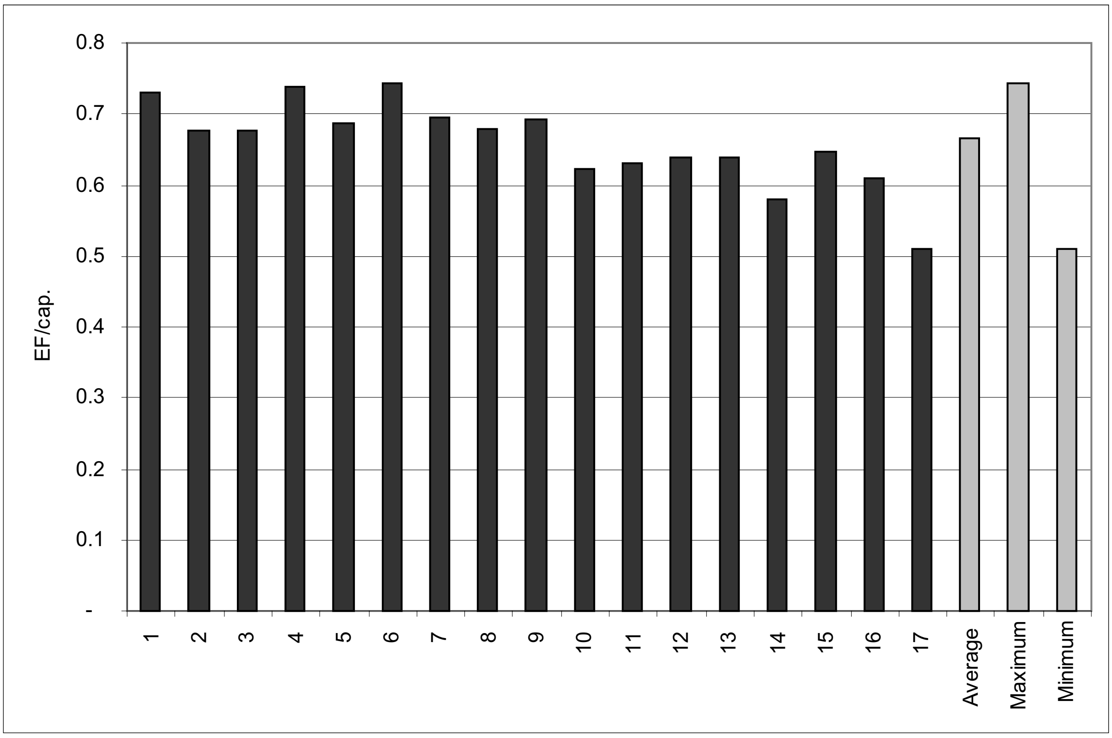

Figure 21: Ecological Footprint of Consumables by different ACORN Groups

In terms of the Ecological Footprint, ACORN groups' 1, 4 and 6 have the greatest impact. An analysis of ACORN group 1 highlights that 33 per cent of the Ecological Footprint is due to the purchasing of recreational goods. This includes games and toys (including computer games, sports equipment, garden equipment and plants, and pet food and accessories). Newspaper accounts for 5 per cent of total impact. When looking at newspapers, it is clear to see which ACORN groups by the broadsheets (average weight of 500g for a broadsheet compared with 150g for a tabloid). Such information could be used to link potential waste streams with ACORN groups.

While Group 11 does not have the most significant Ecological Footprint, it does have a particularly high impact due to the purchasing of household appliances. This suggests that certain groups are more likely to replace durable goods before the end of their lifetime. In terms of the Ecological Footprint this can have advantages and disadvantages; the advantage being the introduction of more energy efficient appliances, disadvantage being the extra material and energy input into the production of more products. When looking at the electricity consumption of ACORN group 11, it is considerably lower than most of the other groups (in fact 13 groups have a higher EF). If we assume that approximately 35 per cent of electricity is for appliances, it is possible to suggest that the extra energy requirements to provide group 11 with new appliances is saved through the use of more efficient appliances. A possible analysis and application of the data is to consider which ACORN groups should be targeted in an effort to replace inefficient durable goods.

Another interesting analysis of the data is to compare the Ecological Footprint with debt. In the UK, 8.5 per cent of the population never pay their credit card off in full at the end of each month. ACORN groups with the largest Ecological Footprint (4 and 6) also are the most likely groups to never pay off their credit card. This suggests both a financial debt and an ecological debt are occurring due to their consumption patterns. In contrast to this, group 16 also has difficulties paying off their credit cards but has quite a low Ecological Footprint. Group 16 (Council estate residents, greatest hardship); do have the lowest income among all the ACORN groups, suggesting that they need to get into debt to provide basic requirements.

Interesting Findings

- The smallest Ecological Footprint of an ACORN group for consumables is 0.51 gha/cap while the largest is 0.76 gha/cap.
- There is clear link between economic debt and ecological debt, suggesting that individuals are borrowing both money and resources from the future.
- It can be more efficient in terms of the Ecological Footprint to replace durable appliances regularly.

8.3.4 HOUSE AND ENERGY

The majority of the Ecological Footprint for "House and Energy" of all the ACORN groups is the direct energy requirement. A small percentage can be attributed to house maintenance and the embodied energy of a house. The results show a distinctly different pattern to the other components. The variation in energy use is substantial, particularly in one ACORN group.

Unlike the other components, some of the lower income ACORN groups have a significant Ecological Footprint. Groups 15 and 17 demonstrate this pattern. Two groups with a lower Ecological Footprint (Groups 4 and 5) do have a high income, these groups being "affluent executives" and "well-off workers" both with families. These households may therefore have a large household occupancy where they are able to share the energy among them. It is well documented that larger households use a lower amount of energy per person. An Incpen study[106] in 2001 highlighted the fact that a household with four residents will use 50 per cent less energy than four individuals living in separate houses. This statement is further supported as the ACORN groups with a lower household occupancy have a higher Ecological Footprint (Groups 6,7 and 8).

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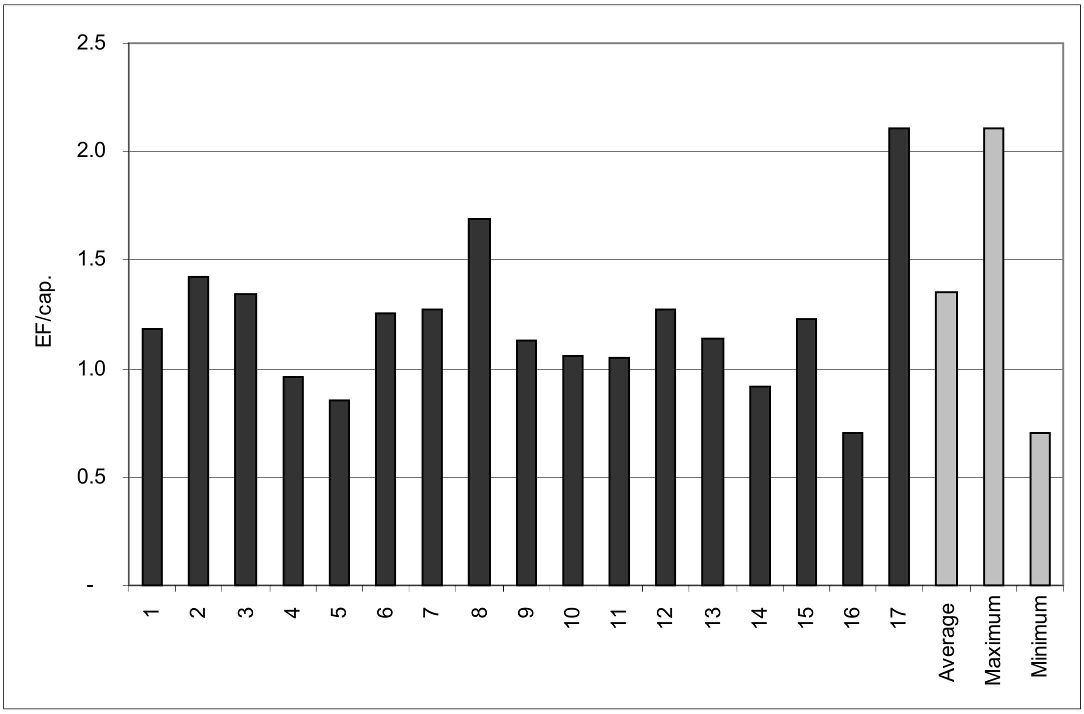
[106] Incpen (2001) Towards Greener Households – Products, Packaging and Energy, Incpen.

Figure 22: Ecological Footprint of Energy by different ACORN Groups



This conclusion, however, does not work for all the ACORN groups; group 17 in particular. Group 17 (Multi-Ethnic, low income areas) has a substantially higher Ecological Footprint. Group 15 (Council estate residents, high unemployment) also has a noticeably high Ecological Footprint. There is no obvious reason why this is the case. One suggestion could be the condition of the housing stock. A suggestion specifically for group 15 could be related to the fact that individuals may spend more time at home due to high unemployment in this group. This finding is supported when looking at the ACORN group that includes students who also may spend a greater amount of time at home (having a 20 per cent higher Ecological Footprint than the average). Both of these suggestions raise the issue of "Fuel Poverty" and the high potential of a "Win Win" scenario related to energy efficiency measures both improving the quality of life and reducing the Ecological Footprint. Information about the energy use of different ACORN groups could be used to establish "High Priority Action Areas" where the most benefit could be achieved.

Interesting Findings

- There is a large variation in the Ecological Footprint of energy by ACORN groups (74 per cent).
- The results not only highlight the ecological dimension but also raise the important issue of fuel poverty suggesting that key groups should be targeted.
- Household occupancy size is a key factor in the Ecological Footprint of energy.

8.3.5 HOLIDAYS

In Wales approximately 65 per cent of the total population went on an overseas holiday. Among the majority of ACORN groups, overseas holidays are seen as the norm and are an ever-increasing phenomena. Even though the majority of Welsh residents went on an overseas holiday, there are specific ACORN groups that are likely to go on more than three overseas holidays a year.

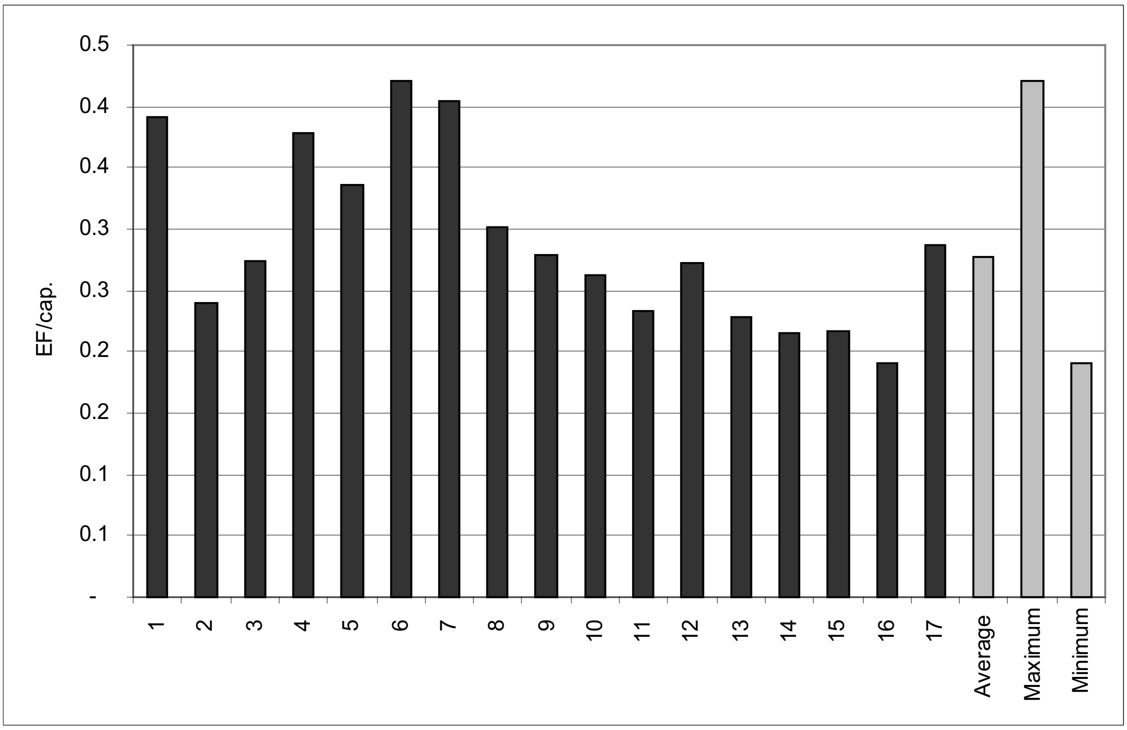


Figure 23: Ecological Footprint of Holidays by different ACORN Groups

There is a significant variation in the Ecological Footprint of ACORN groups in relation to holidays. There is a 62 per cent difference between Group 6 and 16. As with many of the components it is the ACORN group on the lowest income in the most hardship that is not able to enjoy a holiday in comparison to ACORN groups that will go on more than three overseas holidays a year. The results are even more extreme when looking at the more detailed breakdown on ACORN groups (i.e. the 54 breakdown). The "Highly Paid Executives" have an Ecological Footprint for holidays that is 365 per cent higher than the group with the lowest impact. The fact that there is a rapidly growing trend in overseas holidays is a worrying trend in ecological terms.

The aviation industry has grown, and will continue to grow, at an extremely rapid rate. While there has been a major debate concerning the environmental impact of road transport, the impact of aviation has, in the main, been ignored. In fact, aviation has a faster growth rate then any other form of transport. A forecast of worldwide aviation growth produced by the Department of Trade and Industry predicts a growth in air travel of approximately 625 per cent by 2015. Taking into account the predicted growth in car travel, air travel will contribute to over 38 per cent of the Ecological Footprint of passenger transport by 2025. In less than 15 years, the Ecological Footprint of air travel will have increased by 32 per cent. By 2025, air travel will contribute more to the Ecological Footprint and carbon dioxide emissions than other forms of transport.

It is also interesting to note that a tourist visiting the UK does not consume the same as the average UK resident. Chapter 2 explains the methodology used to calculate that the average overseas tourist has an Ecological Footprint of 9.8 gha./cap. This means that the more time spent on holiday the greater the impact will be. Even though the majority of the impact of the holiday is aviation that fact that our consumption patterns differ considerably is interesting, allowing us to consider how this could be reduced.

Interesting Findings

- There is a 62 per cent variation between the lowest and highest ACORN groups.
- The Ecological Footprint of holidays is continuing to grow amongst most of the ACORN groups.
- In as little as 20 years the Ecological Footprint of holidays could be higher than other personal travel.

8.3.6 TRAVEL

The results demonstrate that it is the wealthier more affluent groups that have a larger Ecological Footprint than low income groups. Expenditure on fuel is very high in ACORN groups 1 and 2. The variation in the Ecological Footprint is also substantial.

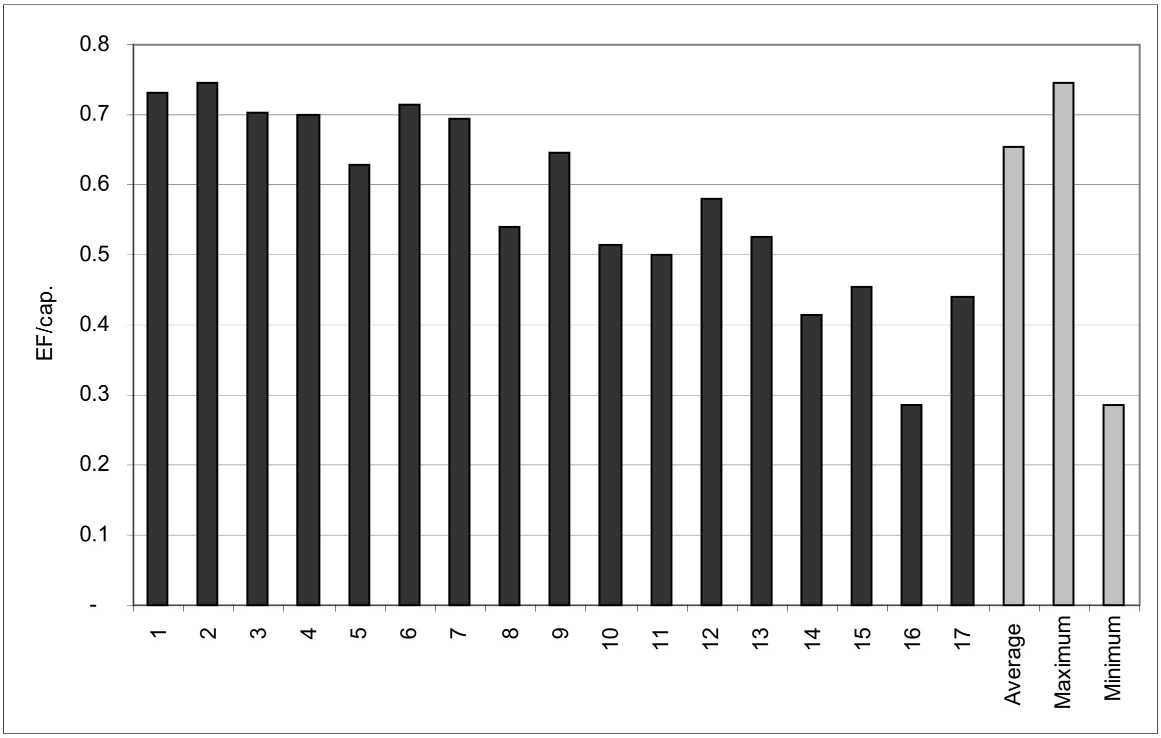


Figure 24: Ecological Footprint of Personal Travel by different ACORN Groups

It is not too surprising that ACORN Group 2 has the largest Ecological Footprint, as this group is made up of affluent people living in a rural area. While there are some similarities with other components there are some differences. Groups 1 to 4 have noticeably higher Ecological Footprints than other components. There appears to be a clear link between income and the Ecological Footprint of personal travel.

Two groups have a larger than average reliance on transport services. Group 7 (Prosperous Professionals, Metropolitan areas) do use the train to move frequently. However, their Ecological Footprint for car is still high suggesting that they commute with the train and then drive for other purposes. The other group with a significant reliance on public transport is group 17. In this case it is the bus that is used most frequently.

The Ecological Footprint is not made up purely of car fuel but also the purchasing and maintenance of cars as well as public transport. Groups 1 to 4 replace their cars frequently while Groups 14 to 17; if they own a car, hardly ever replace it. You might think that this would bring about an increase in the efficiency of the cars driven by Groups 1 to 4, but this is not the case. One reason for this could be the type of car bought by different ACORN groups. Figure 25 gives a brief insight into the Ecological Footprint of travelling the same distance in a number of different car types.

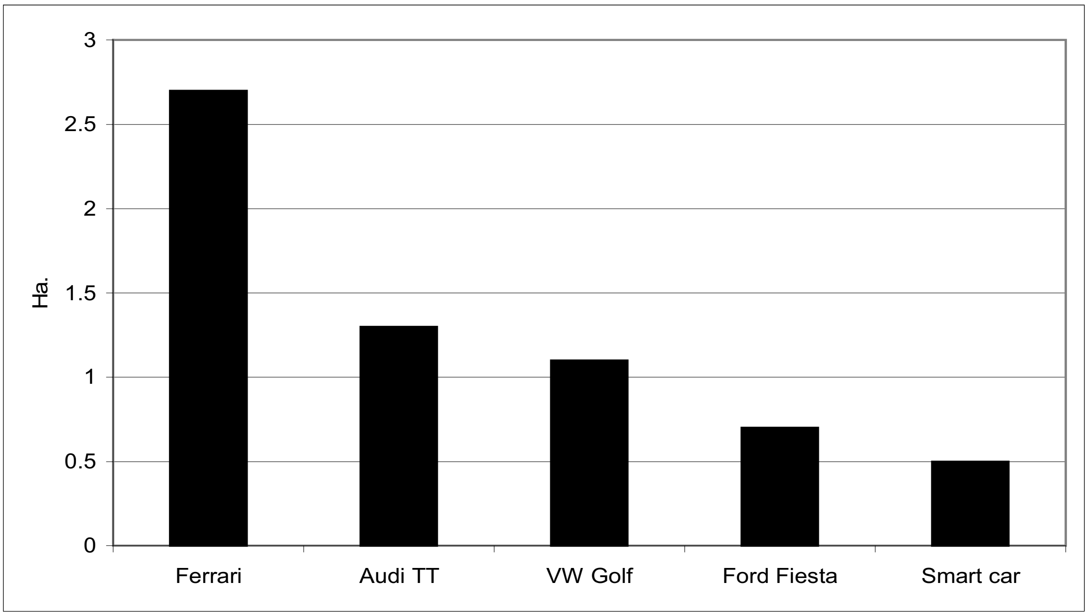


Figure 25: Ecological Footprint of Different Car Types

It is fair to say that cars regarded as being “executive” have a higher Ecological Footprint, however new they might be. Over the past 30 years there has been very little gain in the efficiency of cars due to the introduction of larger engine sizes and gadgets.

Interesting Findings

- Wealthy households who live in rural areas have, by far, the most significant Ecological Footprint for their personal travel.
- Older households have, on average, a lower Ecological Footprint than households with families.
- Many ACORN groups with a lower income are reliant on the provision of affordable and efficient public transport.

8.3.7 SERVICES

While the other components have highlighted the impact of the purchase of material goods, this section explores the varying reliance that different ACORN groups have on services. In essence, we could suggest that the economy should be providing services rather than materials. It has been argued that services could be a powerful tool to help bring about a more sustainable economy (Jackson, 1996[107]). However, it is important to recognise the fact that the service sector consumes resources for us to provide the service. Jackson argues that the service sector does have the power to deliver a more sustainable society partly because services do not base their profitability on the increased throughput

[107] Jackson T. (1996) Material Concerns – Pollution, Profit and Quality of Life, Routledge.

of materials but on the efficiency of service provision. This alone gives an incentive to reduce resource consumption and increase resource productivity.

However, the results of an analysis of the service sector by different ACORN groups shows that it is groups that demand the most in terms of materials that are using the service sector most often. The other result is that services are used by city dwellers that have a larger disposal income than other groups.

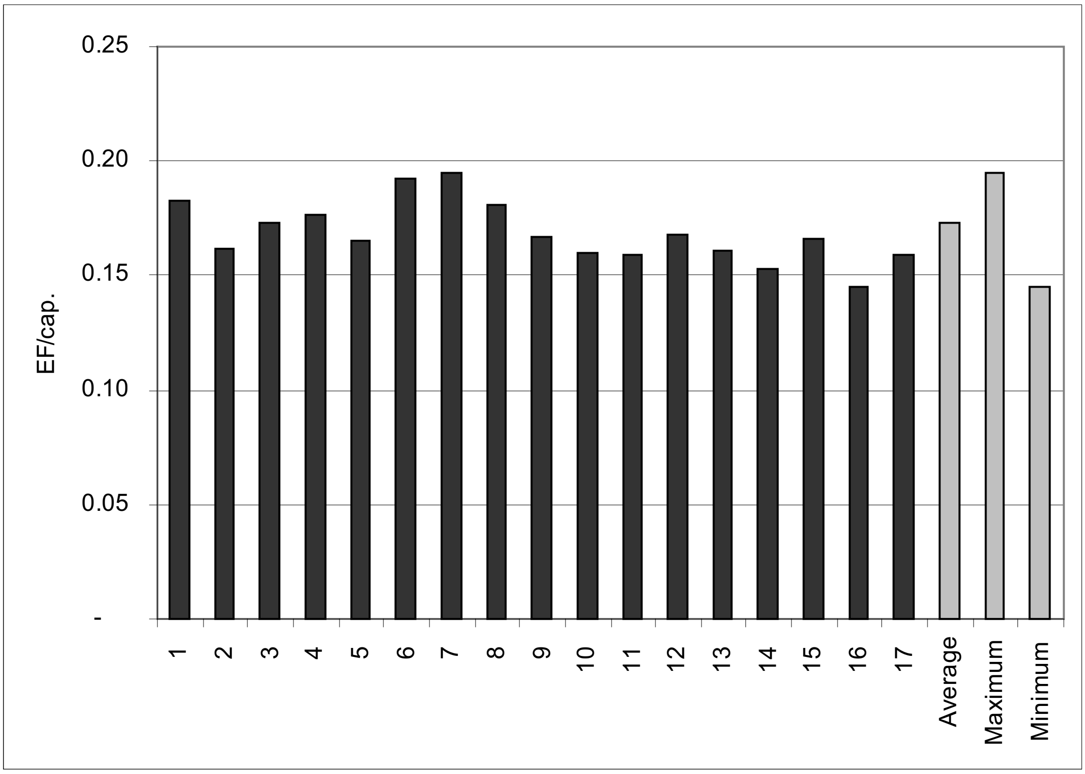


Figure 26: Ecological Footprint of the Service Sector by different ACORN Groups

Group 6 and 7 both live within cities and have a large disposal income. The majority of their impact comes from the use of recreational and cultural services. To name a few they include the use of swimming pools, golf courses, fitness centres, tennis courts as well as cinemas, theatres and opera houses.

In conclusion, the situation has not arisen where basic activities have been replaced by the use of services. Moreover, services provide activities for the select few who generally have a high income and live within a city or large town.

Interesting Findings

- The majority of the Ecological Footprint for the service sector is the provision of recreational and cultural activities.
- The variation in the Ecological Footprint of services by different ACORN groups is not large as some services are used by all groups (insurance being an example).
- There is little evidence to suggest a shift from ownership to services is occurring.

8.3.8 THE TOTAL ECOLOGICAL FOOTPRINT OF ACORN GROUPS

The Ecological Footprint of different socio-economic groups varies considerably. The difference between the Ecological Footprint of the ACORN groups with the highest and lowest is 41 per cent. Other important findings include:

1. Even the people with the lowest Ecological Footprint have an Ecological Footprint that can be regarded as unsustainable in ecological terms.
2. The 41 per cent variation can be related to the buying of luxury goods and going on more overseas holidays.
3. There is no evidence to suggest that as an individual becomes wealthier their Ecological Footprint reduces.
4. The groups that donate the greatest amount of money to environmental and wildlife charities have the highest environmental impact.
5. There is a clear link between expenditure and environmental impact.

The variation in the overall Ecological Footprint of ACORN groups is substantial. The greatest extreme is an Ecological Footprint of 7.03 gha/cap compared with 4.10 gha/cap. The reason why some groups have a lower Ecological Footprint is not due to choosing an "environmentally friendly" lifestyle. In most cases it is due to lower income expenditure not allowing them to purchase luxury goods or go on exotic holidays.

The following diagram explores the relationship between income and the Ecological Footprint.

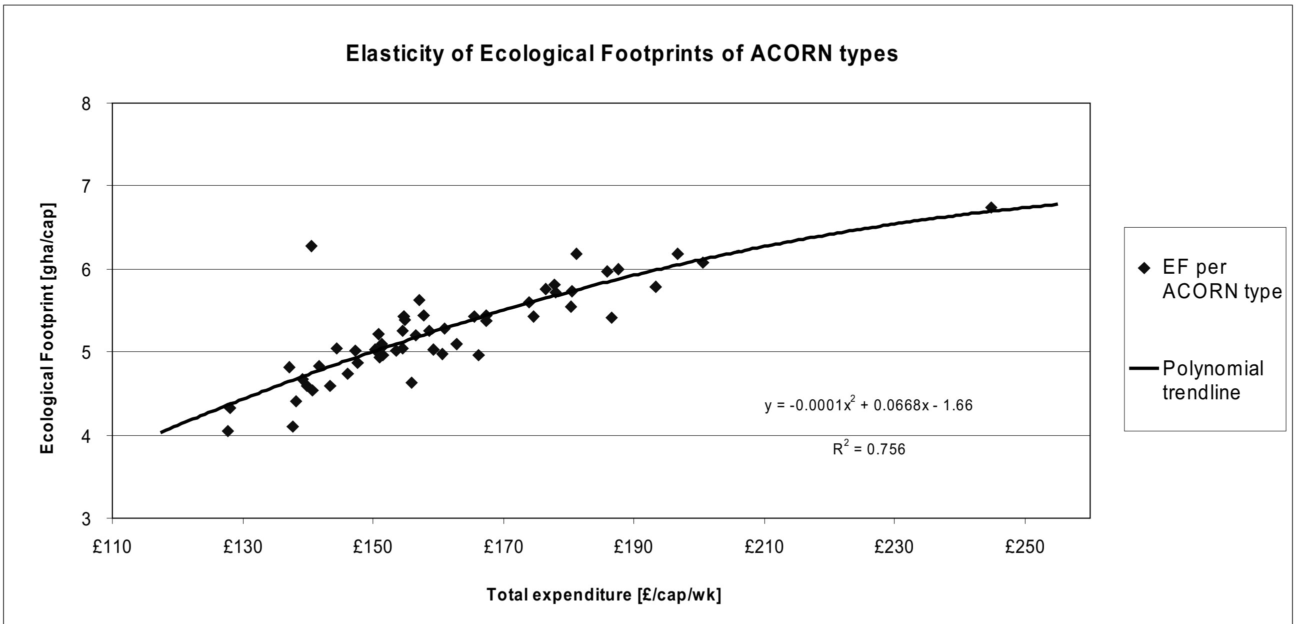


Figure 27: Elasticity of Ecological Footprint of ACORN Groups

Ultimately, it would be useful to know whether an individual on a high income could have a low Ecological Footprint. Even though there is not an ACORN group that captures all the people that attempt to lead a more sustainable lifestyle, it is possible to construct a group that does.

The largest ACORN group in Wales is group 10 (Skilled workers, home owning areas). This group has a lower Ecological Footprint than the average Welsh person (5 gha/cap.). Their Ecological

Footprint is closely related to their income. It is possible that this group could reduce their Ecological Footprint to about 4 gha/cap. through the purchasing of organic food, not eating meat for every meal, a well-insulated house, not always taking the car to work and buying more “environmentally friendly” products. These are changes that can be made without a significant change in lifestyle.

Further changes would, most likely, require a change in lifestyle and something that most people would find difficult or unacceptable to implement (i.e. aviation). Therefore the results do demonstrate that under the current political and economic context it is difficult to achieve a sustainable lifestyle. Further evidence of this was provided in the “Eco-Homes” assessment undertaken by SEI[108]. Even the keen residents in the Eco-Homes had an Ecological Footprint of 3.5 gha/cap.

On a more optimistic note there are many options available to bring about a more sustainable lifestyle and any reduction in the Ecological Footprint must be seen as a positive step in the right direction.

8.4 Policy Options for the Welsh Assembly

In the “Economic Strategy” for Wales there is clear target to increase household disposal income. The target states that by 2010, household income in Wales will increase to 95 per cent of the UK average, currently being 87.5 per cent. This policy would obviously have an affect on the way that people consume in Wales. There is no subsequent target to minimise the potential increase in the environmental impact of consumption. There is also the belief that increased disposable income will bring about an improvement in quality of life. Therefore, the target fails to address environmental issues, ignores the issue of quality of life and purely concentrates on increasing economic growth.

Outside the Welsh Assembly, the Welsh Consumer Council have produced the report, “Policies for Sustainable Consumption in Wales”. The report offers a number of options to bring about a more sustainable future for Wales. One of the key recommendations calls for a major discussion to start, facilitated by WAG in an effort to get to terms with the complexity of the sustainable consumption debate.

One obvious strategy that the Welsh Assembly could put forward is helping individuals to live a more sustainable lifestyle by making it easier for people. For example, ensuring that there is adequate public transport and encouraging labelling schemes. However, the policy suggestions below go beyond this and cover issues related to bringing about behavioural change in Wales. This section is divided into three categories; Persuasive/soft policies, Influencing/Regulatory Policies and the Development of a Sustainable Consumption Strategy.

[108] See Chapter 7 for further details

8.4.1 PERSUASIVE / SOFT POLICIES

The following policy options are concerned with providing the consumer with better information or attempt to adapt behaviour. They can be described as "soft policies".

- **Labelling**

One of the disadvantages with a globalised economy is the fact that the production and consumption process is separated. The consumer has little understanding of the industrial processes, the environmental impact and social consequences involved in the production of a specific product. One approach is to ensure that a product is clearly labelled to give the consumer a greater understanding of the environmental and social issues related to a specific product.

Eco-labelling is a market-based instrument with dual aims: to enable consumers to make environmentally informed purchasing decisions; and to encourage manufacturers to produce more environmentally friendly products. There is evidence to suggest that there is a market for products that achieve a high standard in terms of environmental and social issues. Doane (2002[109]) provides evidence to suggest that the purchase of ethical goods is increasing at a rate of 10 per cent a year.

To date however, labelling schemes have only been successful for specific products. Evidence suggests that the labelling schemes have been more successful when they are mandatory, implying that a strong government intervention is required.

However, it is also important to recognise the limitations of eco-labelling. One of the reasons for the potential success of eco-labelling schemes is the fact that individuals are able to change the product they buy without changing their lifestyle. This is obviously a good thing, however in some of the lifestyle activities a more fundamental shift is required, one that requires individuals to re-address they way they travel, the holidays they choose etc. There is also the concern that improvements in technology are regularly outpaced by increases in consumption. Therefore, the consumption of an ever-increasing number of resources could outpace the gains made by a successful eco-labelling scheme.

Finally, there is a concern that the ACORN groups who are more likely to buy these products are responsible for considerable environmental impact due to large disposable incomes (expenditure on aviation, luxury food items and numerous consumables). As there is often a premium on "environmental friendly" concerns it could be argued that the scheme is for a select group in society.

- **Education – Individualised Marketing**

Growing evidence suggests that targeted information provided in a useful and appropriate format can be very successful at bringing about a positive change in behaviour.

The tool of "Individualised marketing" has mainly been used to influence transport behaviour. Such a scheme entitled, "Intelligent Travel[110]" aimed to examine the potential for changing travel behaviour by reducing car use and encouraging walking, cycling and public transport use which promote health, fitness and a better environment. It tested personalised travel planning on a random sample of 5,701

Doane (2002) Ethical Purchase Index 2002, Cooperative Bank.

[110] For further information please visit: www.sei.se/intelligenttravel

households living in three wards of the City of York, using before and after questionnaire surveys to measure the effect on personal travel behaviour.

The Intelligent Travel interventions produced a 16 percentage point reduction in car trips. This is the overall result for all project areas. The change over the same time period in the non-intervention group was a 5 per cent increase in car trips. Intelligent Travel has converted a potential 5-percentage point increase in car trips into a 16-percentage point reduction. The York Intelligent Transport project has demonstrated that car trips can be reduced through a behavioural change programme. There is no reason why such a method could not be used in other areas of environmental concern, waste management for example. It is also the case that any behavioural change programme will still need to operate within a broader context. For transport this could mean parking management, highway space reallocation, footstreets, cycling facility enhancements and improvement in the quality and quantity of bus and rail provision. For waste this could mean the provision of door-to-door recycling schemes and "pay by weight" schemes.

It is important to remember that "Soft factors" are not a substitute for other measures. They will work best in combination with other measures.

- **Eco-Teams**

In "Policies for Sustainable Consumption", Jackson and Michaelis suggest that there is,

"…an assumption that many people have attitudes consistent with moving towards environmentally sustainable behaviour, but that they do not have sufficient information to do so, nor do they believe that they alone can make a difference. Hence a collective, community-based approach is crucial."

Past research, mainly opinion polls (e.g. Gallup & Newport, 1990[111]), suggest that the public is 'highly concerned' about the environmental problems society faces today, with over 90 per cent of the survey 'worried about the environment'. However, key indicators of sustainability, such as the Ecological Footprint, highlight the continuing and increasing damage to the environment due to environmentally destructive lifestyle choices. Some groups viewed sustainable development as a threat to their high standard of living. There was almost a fear that they would personally have to reduce their standard of living to the same standard as a third world existence.

According to Johnson and Pattie (1999[112]) attitudes and behaviour are mutually interdependent. The attitude maintains the desire for a better environment and improvement in health. Whereas, the behaviour is very different: the continual use of the car and a failure to adopt sustainable transport options.

According to Burgess and Harrison (1998[113]), the collective analogue to this process of deliberation is public discourse and debate. The issues involved in the translation of sustainability from an abstract, academic concept to a regulative social principle requires the consideration as well as the consent and action of those whose lives will be affected by the transition.

In conclusion, any approach that ensures a greater sense of community and social responsibility is likely to bring about a positive change to society. Eco-teams are seen as one of these options where

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[111] Gallup G. & Newport A. (1990) The Polls-Poll Trends: Environmental Problems and Protection, *Public Opinion Quarterly* 55, 651-672.
[112] Johnston R. & Pattie C. (1999) Aspects of interrelationships of attitudes and behaviour as illustrated by a longitudinal study of British adults: 1. Interactions among attitudes and changing voting intentions, *Environment and Planning A*, Vol. 31, 899-923.
[113] Burgess J. & Harrison D. (1998) *Making the abstract real: a cross-cultural study of public understanding and global environmental change*. Department of Geography, University College London.

groups of concerned individuals are able to share experiences and an understanding of sustainability issues. Eco-teams could be supported by the Welsh Assembly demonstrating a commitment to small community groups attempting to lead a more sustainable lifestyle. Jackson and Michaelis provide evidence suggesting that Eco-teams have typically achieved reductions in car use and consumption of energy and water of around 10 per cent, and reductions in waste of around 40 per cent.

- **Focused Information to Specific Socio-Economic Groups**

One of the key findings of the results is the fact that different ACORN groups consume in vastly different ways and have extremely diverse impacts on the environment. As Axelrod & Lehman (1993[114]) have suggested, the importance of investigating the psychological antecedents of individuals' reactions to environmental concerns is vital, as we attempt to better understand the factors that guide individual choice regarding environmentally responsible behaviour. Information provided by the above analysis is crucial in reducing impact and also attempting to improve the quality of life of specific groups.

8.4.2 INFLUENCING/REGULATORY POLICIES

The following policy suggestions rely on a change in regulation albeit waste, planning or changing work hours. They are policies options that can be undertaken within the current political climate and often require a small change to an existing policy.

- **Ecological Taxation**

At present the Welsh Assembly has no ability to change taxation, this is a role for central government. However, this does not mean that there is not a key role to play for the Welsh Assembly Government in ensuring that Welsh residents are aware of a number of eco-taxes that have been put in place by central government.

At the moment a number of ecological taxes are in place. However, it would be fair to say that the general public are not aware of the taxation (landfill tax being a good example) or do not perceive that the tax is in place for environmental reasons (i.e. fuel tax). In many cases that is a lack of trust in government, believing that it is yet another tax implemented through a dubious route. Moreover, environmental reasons are not given to justify the policy choice even if that was the intention.

It is suggested that WAG should help inform the public of the existence of eco-taxes, particularly the Landfill Tax.

- **Planning**

Chapter 7 clearly highlights the benefits of building Eco-Homes to the standard of BedZed. Demonstrating that energy savings of up to 90 per cent are possible as well as changing the need for travel suggests that making it easier through the planning process to build Eco-Homes is an essential policy option for WAG.

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[114] Axelrod L. & Lehman B. (1995) Characterizing perception of ecological risk, *Risk Analysis*. 15 (5), pp 575-588.

- **Household sizes and shared resources**

Household occupancy in the UK has been gradually declining over the past decade. This is one of the reasons for an increasing demand for new houses. As more and more people want to live alone there is an increased consumption of resources and energy per person. As previously suggested, there is a 50 per cent increase in energy per person if living alone, compared to a high occupancy dwelling.

One option is to ensure that shared resources are made available in low occupancy developments in an attempt to avoid increased consumption. Within the planning process there is the option to ensure that developers encompass shared facilities into the design of apartments.

- **Aviation and Sustainability**

The demand for air travel is forecasted to double over the next 20 years. This growth is clearly unsustainable for a variety of reasons. Notably, greenhouse gas emissions (GHGs) will rise substantially over this period, which is in conflict with international agreements aimed at reducing them.

Even though WAG does not have control over aviation policy in the UK there are a number of steps that they could support in an effort to address the issue. From the suggestions put forward in a recent report by the Stockholm Environment Institute, these are the suggestions that WAG could help implement:

4 The adoption of World Health Organisation recommended values on noise thresholds and implementing policies to deliver a healthy noise environment. The implementation of surface access strategies that can deliver at least 50 per cent of all passengers to and from airports by non-car modes of transport.
5 The adoption of the environmental bubble concept to give airports clear quantitative limits for a small set of pollutants.
6 A ban on night-time flights (2300-0700 hrs) to protect human health.
7 Governmentally supported strategies delivered by clearly defined partnerships to shift passengers from air transport to rail for journeys of up to 500km in length.

- **Rebound Effect**

A *Rebound Effect* refers to increased consumption that results from actions that increase efficiency and reduce consumer costs (Musters, 1995[115]; Alexander, 1997[116]; Herring, 1998[117]). For example, a home insulation program that reduces heat losses by 50% does not usually result in a full 50% reduction in energy consumption, because residents of insulated homes find that they can afford to keep their homes warmer. As a result, they reinvest a portion of potential energy savings on comfort.

[115] Musters A.P.A. (1995) *The Rebound Effect: An Introduction*, Netherlands Energy Research Foundation (www.ecn.nl), 1995.

[116] Alexander M. (1997), *The Rebound Effect in Energy Conservation*, PhD Dissertation (www.leprechaun.com/econ.html), 1997.

[117] Herring H. (1998), *Does Energy Efficiency Save Energy: The Implications of Accepting the Khazzoom-Brookes Postulate*, EERU, the Open University (http://technology.open.ac.uk/eeru/staff/horace/kbpotl.htm), 1998.

The difference between the 50% potential energy savings and the actual savings is the Rebound Effect (Victoria Transport Institute, 2004[118]).

Therefore, a program or technology that reduces consumers' costs tends to increase consumption. For example, strategies that increase fuel efficiency or reduce traffic congestion, and therefore reduce the per-mile cost of driving, tend to increase total vehicle mileage.

This is not to suggest that Rebound Effects *eliminates* the benefits of efficiency gains. There is usually a net congestion reductions or energy savings after the Rebound Effect occurs. However, the Rebound Effect can significantly change the nature of the benefits that result from a particular policy or project. Research undertaken at the Toyohashi Sozo College, Japan suggests that the size of Rebound Effect is estimated to be between 35 to 70 per cent (Washida, 2004[119]).

Ultimately, the problem exists that some groups in society will always have a disposable income to purchase an increasing amount of consumables. The Rebound Effect does raise some fundamental questions about the economy and increased desire to purchase more and more products. For WAG, initially it is important to acknowledge the Rebound Effect and address the issue that increases in GDP are seen as a key driving force for most policy decisions. A better work/life balance would help promote the importance of quality of life as opposed to standard of living. WAG has a key role to play in education and awareness raising as well as encompassing these ideas into policy decisions.

8.4.3 THE NEED FOR A SUSTAINABLE CONSUMPTION STRATEGY

At present it is difficult to find many of the concerns raised in this report within the policies of WAG. Therefore, we would suggest a strong need for a comprehensive and coherent strategy that combines many of the suggestions above while also taking on board new approaches to government. The development of a Sustainable Consumption Strategy could help to inform all policy areas, demonstrate a commitment to the issue and encompass the policies on sustainable consumption that are currently being developed by DEFRA and Dti.

One of the crucial components of such a strategy is the overall acknowledgement that there is no link between increasing levels of economic growth and happiness. Such a fundamental step needs to be endorsed by WAG.

Secondly, clear and strong messages from WAG are required to demonstrate their commitment to the issue of sustainable consumption (technology, innovation and procurement).

The basis of a policy should also combine the issue of a "fair share of resources" as suggested by the Sustainable Development Commission. The research has clearly highlighted that differences in consumption patterns between socio-economic groups are vast.

Finally, the Strategy should be supported by strong indicators that truly reflect the impact of consumption in Wales.

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118 Victoria Transport Institute (2004) Rebound Effects – Implications for Transport Planning (http://www.vtpi.org/tdm/tdm64.htm)

119 Washida T. (2004) Economy-Wide Model of Rebound Effect for Environmental Efficiency, International Workshop on Sustainable Consumption, University of Leeds, March 5-6, 2004, Conference Proceeding.

8.5 Discussion

Jackson and Michaelis (2003[120]) suggest a number of reasons as to why we consume the way we do, suggesting we are "locked in to current consumption patterns" by a combination of market incentives, psychology and conditioning, social structures and norms, institutional frameworks, cultural values and narratives. At the same time it is noted that these are not fixed entities changing over time.

One key shift that has occurred is the changing perception of "luxury" items to "essential" items. Holidays are a good example of this. An overseas holiday is no longer seen as a "want" but can be seen as a "need". Evidence of this, as shown in section 9.3.5, revealed that 65 per cent of the Welsh population now have an overseas holiday, which has an associated environmental impact.

It should be noted that consumption patterns can be vastly different between different cultures and the results demonstrate the differences that occur even within one country. At the same time we are witnessing a convergence of ideas and consumption patterns. The fact that over 80 per cent of the population now shop in supermarkets is a reminder of this fact. In essence this points to evidence that overtime, consumption patterns can change and ideas perceived to be "extreme" or only supported by minority groups can become part of the "mainstream".

[120] [120] Jackson T. and Michaelis (2003) Policies for Sustainable Consumption, Sustainable Development Commission (available at http://www.sd-commission.org.uk/news/index.php?page=get_page&article_id=PXXSKPK-DULDB81-NJKPWJT-9BJLZPJ)

9. Appendix – Methodology

A.1 Introduction to Resource Accounting

Figure 28 highlights the basic structure of the material flow analysis (MFA). It outlines the flow of energy and resources through the human economy. After resources have been extracted from the natural environment they are processed into goods and services for households. Waste is produced at this stage as well as later by households. After extraction, water will be used by industry and services or directly by households. Wastage occurs at the extraction and distribution level. Industry and households will also produce waste water. Greenhouse gas emissions (GHG) are produced at every stage of the material and energy flow (energy production, production of goods and services, household consumption and waste management).

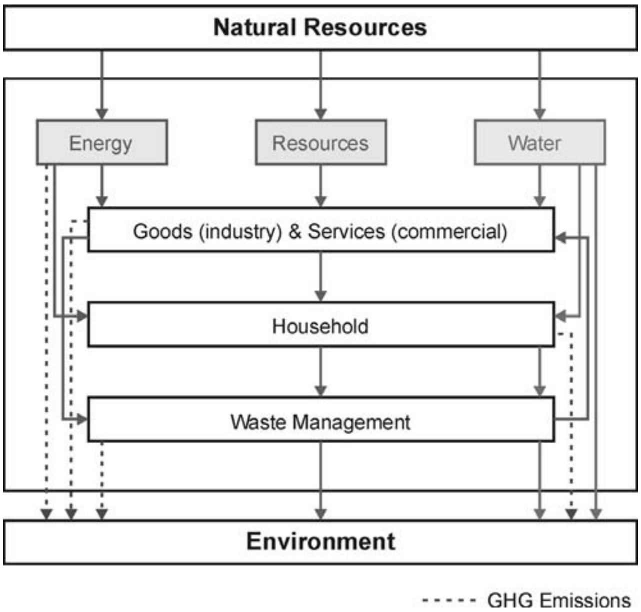

Figure 28: Flow of Resources through the Economy (Adapted from Noorman and Uiterkamp 1998[121])

The study provides a comprehensive description of material flows between the environment and economy as well as within the economy (production and consumption), distinguishing not only categories of materials but also branches of production[122]. This approach is applied throughout the study and incorporates all the material and energy flows of a given population (Wiedmann et al., 2004). It is combined with a detailed Input-Output approach. The I/O approach adds a considerable depth to the research (Wiedmann et al., forthcoming). The method has been used to calculate both material flows and the Ecological Footprint. The methodology has been explained in the context of the Ecological Footprint and then the data sources for material flows has been identified.

[121] Noorman and Uiterkamp (Ed.) (1998) *Green Households? – Domestic Consumers, Environment and Sustainability*, Earthscan.

[122] Eurostat (2000) *Economy-wide Material Flow Accounts and Balances with derived resource use indicators: A Methodological Guide*, Eurostat.

A.2 Calculating the 'standardised' Ecological Footprint of the UK

In this chapter we describe a methodology that allows to allocate Ecological Footprints obtained with the National Footprint Accounts (NFA) method to industrial activities, final demand and household consumption using an input-output analysis. The term 'standardised' is set in inverted commas because at the time when this report has been written there was no commonly agreed standard methodology yet for calculating the Ecological Footprint of nations and sub-national regions. The Global Footprint Network, together with the worldwide Ecological Footprint community, is currently developing quality assurance standards that shall guide use of the method and reporting of results. A Standards Committee is currently being created in order to formalize and accelerate this process. The goal is to establish ever improving, transparent quality standards for Ecological Footprint accounting as well as for the communication of findings. The method described in this report is contributing to the development of a standardised Ecological Footprint on a national, regional and local scale as it uses a consistent calculation framework while at the same time allowing the NFA method to develop.

A.2.1 INTRODUCTION

The Ecological Footprint is an aggregated indicator of land area which is required to sustain the consumption of a given human population and therefore can be seen as one measure of ecological sustainability (Wackernagel and Rees, 1996). Although being widely used, the Ecological Footprint concept has been criticised for not accurately reflecting the impacts of consumption (van den Bergh and Verbruggen, 1999; Lenzen and Murray, 2001; Ferng, 2002), for not correctly allocating responsibilities (Herendeen, 2000; McGregor et al., 2004b) and for not being useful for policy makers (van den Bergh and Verbruggen, 1999; Ayres, 2000; Moffatt, 2000; Ferng, 2002)[123]. Furthermore, there is no commonly accepted method for footprint calculations and thus results from different studies can not be compared directly. In this chapter we try to address some of these issues by presenting a methodology that combines existing footprint accounting with national economic and environmental accounting and allows to allocate direct and indirect environmental impacts to household consumption activities in order to make it more relevant to sustainable consumption policies.

The use of environmental input-output analysis

The traditional method of calculating national Ecological Footprints (the "National Footprint Accounts") is based on a resource balance that takes into account domestic production, imports and exports of primary and secondary products of the country under investigation (Monfreda et al., 2004). A rough estimate for the embodied energies of secondary products takes into account the conversion efficiency from primary to secondary products. The method distinguishes between national conversion efficiency for domestically produced products and global conversion efficiency for imports.

In total, this results in a Footprint for apparent consumption but on a sectoral level this method does not assign resource flows accurately to final consumption categories, because it leaves out all the mutual interrelationships between production sectors. Furthermore, it does take into account the

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[123] For a more general debate on the Ecological Footprint, see the March 2000 issue of Ecological Economics (Volume 32, Issue 3, Pages 341-394) as well as Ferguson (2001) and Van Vuuren and Smeets (2001).

environmental effects of ‘tertiary’ products, e.g. services. Service industries often use very little resource inputs directly. However, they trigger resource flows indirectly, because they use numerous intermediate products from other industries for their service provision. Hendrickson (2001) and Suh (2004a) show that those indirect requirements account for the majority of resource use of services and make them far from being negligible in terms of total resource consumption.

Environmental extended input-output analysis (Leontief, 1970; Miller and Blair, 1985) is a well established approach that allows to consequently assign intermediate resource flows to final consumption. Some recent examples for the use of environmental input-output analysis include an environmental input-output calculus for the United Kingdom (Vaze, 1997), material flow calculations at the national level (Hinterberger et al., 1998; Moll et al., 1998), primary energy and greenhouse gas embodiments in goods and services (Lenzen, 1998), evaluation of regional ecological sustainability using the dissipation area of emission flows (Eder and Narodoslawsky, 1999), analysis of global trade based on a weak criterion of sustainability (Proops et al., 1999), estimation of land use changes in China (Hubacek and Sun, 2001), pollution attribution (McGregor et al., 2001), assessing the environmental impacts of environmentally motivated spending options (Lenzen and Dey, 2002), interdependence of industries in terms of environmental pressure and resource depletion (Lenzen, 2003), environmental impact assessment of a development proposal (Lenzen et al., 2003), calculation of region-specific fuel-use and pollution coefficients (Turner, 2003), allocation of waste generation and disposal (Allan et al., 2004a; Allan et al., 2004b), an environmental trade balance between Scotland and the rest of the UK (Ferguson et al., 2004), and Life Cycle Assessments (LCA) based on input-output analysis (Suh, 2004a and 2004b).

Several studies have applied input–output analysis to modify the Ecological Footprint framework, detailed examples of which have been given in the following.

Bicknell et al. (1998) were the first to present a way of calculating Ecological Footprints by using an input–output methodology. The total Ecological Footprint of New Zealand is derived by using real land use data and by incorporating embodied energy multipliers in an 80 sector input-output framework. The results are aggregated to the following land categories: degraded land, energy land, agricultural land, imported land, forest land. Bicknell et al.’s methodology has recently been extended by McDonald and Patterson (2004) who generated regional input-output tables and a regional land appropriation model to calculate the Ecological Footprints and interdependencies of 16 regions in New Zealand. The results are presented for the Auckland region in detail and are disaggregated by land type and economic sector.

A detailed and comprehensive account of the Ecological Footprint for Australia was undertaken by Lenzen and Murray (2001). They employ a single-region input-output framework that was partially closed, i.e. capital investment is separated form final demand and internalised into intermediate demand in order to account for resources required for the production of capital commodities. The results distinguish imports, domestic consumption, and exports. The calculations are based on actual Australian land use as well as on land disturbance. Greenhouse gases other than CO_2 and emission sources other than energy use are used and a new land type category ‘emissions land’ is introduced.

The use of aggregated land multipliers by Bicknell et al. (1998) is criticised by Ferng (2001) who uses a composition of land multipliers instead to estimate Ecological Footprints associated with production activities. As final demand draws from various industrial sectors it is crucial to distinguish different land types, like production land and energy land, which are differently associated with those sectors. Ferng demonstrates that significantly different results are obtained by the two methods and applied the revised calculus to the case study of Taiwan.

Ferng also uses both input-output analysis and a computable general equilibrium (CGE) model to construct a comprehensive scenario analysis framework for energy footprints (Ferng, 2002). This allows a more genuine calculation of energy footprints than the original method proposed by Wackernagel et al. (1999) while at the same time avoiding inconsistencies and double counting issues in the latter method. Ferng's proposed framework also allows detailed policy scenario analyses that make footprint calculations more useful for policy makers.

Hubacek and Giljum (2003) first applied physical input-output analysis to estimate land footprints (land appropriation) for the production of exports from Europe arguing that physical multipliers for this kind of calculation would be more appropriate, as the most land intensive sectors are also the sectors with the highest amounts of material flows. In his reply to this paper however, Suh (2004) shows that the results may vary significantly when using physical input-output tables (PIOT) depending on crucial issues like double counting, the treatment of wastes and the effect of closing the system toward direct material inputs.

McGregor et al. (2004a, 2004b) present input-output analysis as an alternative to Ecological Footprint calculations. In their applications to the Jersey and Scottish economy however, they only attribute CO_2 and pollutant emissions to elements of final demand. In order to account for pollution generation and resource use within the geographical bounds of Jersey and Scotland, the authors endogenise trade in the input-output system. This procedure, in essence, allocates pro rata the environmental impacts of production for exports to the sectors and final demand uses that import. By doing so, the responsibility for regional pollution is reallocated to the consumption of the population living in those regions.

The need for consumption activity and expenditure related Ecological Footprints

Although the usefulness of the Ecological Footprint as an operational indicator for decision-makers has been questioned (van den Bergh and Verbruggen, 1999; Ayres, 2000; Moffatt, 2000; Ferng, 2002), the concept is being adopted by a growing number of government authorities, agencies, organisations and communities as a metric of ecological performance. The relevance of the footprint for policy makers can be increased significantly by breaking it down to components reflecting policy areas like energy, transport, housing, waste, etc. (Simmons et al., 2000). Here we go further and calculate Ecological Footprints for consumer activities (COICOP).

Furthermore, the monetary input-output approach adopted allows the exploration of any expenditure pattern linked to final consumption. This allows for the construction of policy scenarios and thus helps informing sustainable consumption policies.

A.2.2 METHODOLOGICAL APPROACH

The method described in this chapter is based on a supply and use table framework (SUT). This allows the application of an input-output analysis without a symmetric (product by product) analytical table. A similar procedure is described by Vaze (1997) and Lenzen (2001). For the United Kingdom in 2004 symmetric analytical tables, including the Leontief inverse matrix, are available only for the year 1995. The intention of this work however was to combine the latest Ecological Footprint calculations from the year 2000 with industrial transaction tables from the same year. Supply and use tables are available from the UK Office for National Statistics (ONS) on an annual basis with a delay of three to four years (ONS, 2003a). For the calculation of the Wales Footprint expenditure data from the year 2001 were used in order to provide the most up-to-date results. Table 75 provides an overview of the supply and use table framework used.

Table 75: Overview of the monetary supply and use framework

	Commodities	Industries	Final Demand	Total Output
Commodities		$U_{m\times n}$	$Y^{com}_{m\times o}$	q
Industries	$V_{n\times m}$			x
Value Added		W		
Total Inputs	q	x		$\sum$

where:
V = matrix for the supply of commodities (m) by industries (n), including imports
U = matrix for the use of commodities (m) by industries (n) = intermediate flows, including imports
$\boldsymbol{Y^{com}}$ = matrix for the final demands (o) for commodities (m)
q = commodity output vector
x = industry output vector
W = value added / primary input matrix

All calculations have been done on a 76x76 sector level. It would have been possible to conduct the input-output analysis on a 123x123 sector disaggregation as delivered by ONS. However, essential energy and CO_2 emission data from the Environmental Accounts are available for a 76 sector breakdown only (ONS, 2003b).

The applied method involves the following steps:
Step 1: create supply matrix (76x76)
Step 2: prepare use matrix (76x76) in basic prices
Step 3: prepare final demand matrix in basic prices and by COICOP
Step 4: calculate direct and indirect requirement matrix
Step 5: associate Ecological Footprints with industrial sectors
Step 6: calculate direct and indirect intensity vectors
Step 7: calculate the Ecological Footprints of final demand categories
Step 8: subtract and endogenise exports

Technical note: All calculations were performed on a desktop PC with Microsoft® Excel®. Specific add-in programmes – 'Matrix15.xla' and 'BigMatrix.xla' (Volpi, 2003) – were used to enable calculations with big matrices in Excel®.

Step 1: create supply matrix (76x76)

A supply table shows the goods and services (commodities) produced by each industry along with the supply of commodities through imports. Industries are classified according to the product that accounts for the largest part of their output (in £). Each industry produces what is termed to be its principal product (shown in the diagonal elements in the supply table). The values of secondary products are shown in the off-diagonal cells. Basically, the supply table presents the relationships between the output of products and the output of industries.

The full (123x123) supply matrix is not published due to the disclosive nature of the data (ONS, 2003). An aggregated (30x30) version with some suppressed data cells is available instead. Also, the percentage of principal products of total industry output and of total output of products is known for each industry. This information allows to update a previous version of a UK supply table from 1998 which was available in a 76x76 sector breakdown. Under the assumption that the proportions of secondary production have not changed the RAS procedure was employed to construct a 76x76 supply table for 2000 (Miller and Blair, 1985). In our version of the table the supply of commodities is presented in the columns while the rows show the industries responsible for the output of these commodities. All numbers are in basic prices.

The imports of products were integrated in the domestic supply table, i.e. the figures for imports and domestic production were joined together in the 76x76 matrix (this is usually referred to as a 'competitive' table and means in economic terms that imports have identical properties and are therefore act as substitutes for domestically produced products). This was done because no separate information on the industrial use of imports was available; the economic use matrix (described below) amalgamates domestic production and imports. The same approach has been adopted before (Lenzen, 2001). However, the environmental impacts of imports were taken into account to a limited extend. This is described in Step 5.

Step 2: prepare use matrix (76x76) in basic prices

The use matrix shows the purchases of commodities and primary inputs used in the production process of each industry. Officially published use tables are only available in a mixed price system rendering it unsuitable for immediate application (ONS, 2003). In order to make the use table consistent with the supply table, the intermediate flow matrix needs to be transformed from purchasers' into basic prices. In particular, this requires the exclusion of direct taxes and distribution margins. A use matrix in basic prices for the year 2000 was courteously provided by Cambridge Econometrics (Lewney, 2004) and integrated with the available ONS data.

Step 3: prepare final demand matrix in basic prices and by COICOP

In the framework of national accounts the final consumption of products is illustrated in the final demand section of the input-output tables. In the UK, a 123 sector breakdown of final demand expenditure is available annually. More importantly, the expenditure of private households is disaggregated by functional headings using the COICOP classification (Classification of Individual Consumption According to Purpose) (ONS, 2003). This allows a detailed allocation of environmental impacts to a number of household consumption activities and provides information directly relevant to sustainable consumption policies.

Step 4: calculate direct and indirect requirement matrix

Supply and use tables can be seen as a preliminary stage in the process of producing symmetric input-output tables. For modelling purposes however, they can be used directly as is described below (Miller and Blair, 1985).

Similar to the standard input-output analysis (Leontief, 1970, Miller and Blair, 1985) technical coefficients b_{ij} and a technical coefficient matrix B can be derived from the use matrix:

$$B = [b_{ij}] = \left[\frac{u_{ij}}{x_j}\right] \tag{1}$$

where: u_{ij} = use of commodity i by industry j (in £) and x_j = total output of industry j including imports (in £). Hence, each element b_{ij} represents the amount of commodity i required to produce one unit of the output of industry j. Therefore, the input-output systems can be written as:

$$q = Bx + y^{com} \tag{2}$$

where: q = commodity output vector; B = technical coefficient matrix; x = industry output vector and y^{com} = vector for the final demand for commodities. To derive the direct and indirect requirement matrix (generally known as the Leontief Inverse in the standard demand side input-output model), information on primary and secondary production needs to be added to the framework. Here, we adopt an industry based technology assumption, i.e. we assume that the total output of a commodity is provided by industries in fixed proportions. Vaze (1997) describes a similar SUT calculus with the difference that a hybrid technology assumption is adopted.

Hence, a coefficient matrix D can derived whose individual coefficients d_{ij} (often called commodity output proportions) are defined as:

$$D = \left[d_{ji}\right] = \left[\frac{v_{ji}}{q_i}\right] \tag{3}$$

where: v_{ji} = supply of commodity i by industry j (in £) and q_i = total (domestic + imported) supply commodity i (in £). Each element d_{ji} represents the part of total production of commodity i that is attributable to the production in the industrial sector j.

The industry based assumption presumes that an industry has the same input structure regardless of the technology mix. Matrix D allows to 'weight' the technical coefficient matrix B in terms of secondary production. A symmetric (industry-by-industry) input-output framework can then be constructed in the following way (Miller and Blair, 1985):

$$x = [(I - DB)^{-1} \cdot D] \cdot y^{com} \tag{4}$$

where: x = industry output vector; I = identity matrix; D = industry-based technology coefficient matrix; B = technical coefficient matrix and y^{com} = vector for the total final demand for commodities. The bracketed term $[(I\text{-}DB)^{-1}D]$ represents the direct and indirect requirement matrix ("Leontief Inverse") of the SUT framework.

Step 5: associate Ecological Footprints with industrial sectors (and direct emissions)

In this project we use the input-output framework to allocate to final demand the Ecological Footprint of the UK for the year 2000 (5.35 gha/cap). However, this footprint was derived with a different method referred to as the 'National Footprint Accounts' (NFA) method. A detailed description of the NFA method can be found in Monfreda et al (2004) and the Living Planet Report (WWF, 2004).

The NFA approach does not distinguish explicitly between imports that are used as intermediate goods and imports that go directly to final consumption. However, most of the materials accounted for in the NFA approach constitute either raw materials or intermediate products. Therefore, the Ecological Footprints of all imports were allocated directly to the industries assuming that they consist of raw materials or intermediate goods that support production. Imports of services are not addressed in the NFA method.

In the method employed, the Ecological Footprint of aviation was calculated separately and was added to the total Ecological Footprint afterwards because more accurate data on passenger kilometres and thus on actual fuel consumption for airplanes was available.

As described above, the SUT framework represents a complete picture of the UK economy showing all inputs (domestically produced goods and imports) and all outputs (domestic final consumption and exports). For this reason, the Ecological Footprint of exports had to be added to the Ecological Footprint of domestic consumption and imports prior to the input-output analysis. As described below, exports were subtracted again after the reallocation of the Footprints.

The Ecological Footprints derived in that way represent the direct impact of the 76 industries, i.e. the environmental pressure caused by land use and CO_2 emissions of UK production activities and imports. In addition to inter-industrial transactions, we take into account activities of private households, which are not represented in input-output tables but are relevant to the Ecological Footprint (emissions from the usage of household fuels and the private car, as well as consumed land in the form of residences, and roads used by private cars).

Footprints were also correlated with the direct consumption of fossil fuels in households and private vehicles. Again, the direct CO_2 emissions from the energy carriers (e.g. gas for heating, petrol for cars, etc.) were used to derive the associated Ecological Footprints. These consumption activities are not included in the input-output framework as the emissions occur after the final consumption of the product and not in the industry during a production stage (the refining and distributing of the fuels however is attributed directly to the respective industries).

All Ecological Footprints were disaggregated in six land types: energy land, crop land, pasture, built land, sea and forests. As Ferng (2001) demonstrated this is crucial to the result because the use of aggregated land types would lead to different results.

Step 6: calculate direct and indirect intensity vectors

The Ecological Footprints per industries are then divided by the total output of these industries at basic prices including imports. The result is a 6x76 matrix – 6 footprint land types and 76 industries – for Ecological Footprints per industry output (in gha/cap/m£), called the direct intensity matrix EF^{dir}. It expresses the Ecological Footprints that are directly associated with the production activities of industrial sectors per £ of their product output.

Postmultiplying EF^{dir} with the 'Leontief Inverse' of the SUT framework results in the total intensity matrix EF^{tot} which takes into account all direct plus indirect impacts of industrial activities arising through the entire industrial supply chain, it represents the full environmental pressure per £ of product output.

$$EF^{tot} = EF^{dir} \cdot [(I - DB)^{-1} \cdot D] \tag{5}$$

The resulting multipliers are 'simple multipliers' (Type I), which means that they describe production-induced effects as facilitated by inter-industrial transactions, but not consumption-induced effects arising out of feedbacks between income and private final consumption.

Step 7: calculate the Ecological Footprints of final demand categories

The last step allocates Ecological Footprints to final demand categories. This is done by postmultiplying the total intensity matrix EF^{tot} with the final demand matrix Y^{com}. This results in the matrix EF^{FD} which shows the individual Ecological Footprints ef_{lo} of final demand category o per land type l:

$$EF^{tot} \cdot Y^{com} = EF^{FD} = [ef_{lo}] \tag{6}$$

A further insight in the detailed make-up of each Ecological Footprints ef_{lo} can be obtained when the corresponding final demand vector Y_o^{com} is diagonalised and the resulting matrix is premultiplied with EF^{tot}. This results in a breakdown of the respective final demand footprint into 76 product categories.

Step 8: subtract and endogenise exports

The Ecological Footprints of exports are treated in a specific way. First, the footprint of exports as calculated with the National Footprint Accounts (NFA) method described above is subtracted from the total footprint after the input-output calculations have been carried out. As mentioned before it has been added prior to the input-output analysis in order to make the calculations complete.

In a second step, the remaining EF for exports (that represent all indirect impacts of exports not taken into account with the NFA method) are redistributed to the other elements of final demand. For this we used a procedure described by McGregor et al. (2003, 2004a, 2004b). In their neo-classical approach, emissions generated by exports (and investment) of the domestic economy are endogenised in the input-output model and redistributed to household and government consumption. Thus environmental impacts embodied in exports are allocated pro rata to the sectors and final demand categories that import. The approach takes the view that exports essentially create the money to finance imports. It has to be emphasised that this method is based on the assumption that environmental impacts per monetary unit of exports and imports are identical.

We adopt this approach to some extent by redistributing only the indirect impacts of exports to other final demand categories and thus accounting for the equivalent indirect impacts of imports which are not considered by the NFA method.

A.2.3 RESULTS OF THE INPUT-OUTPUT APPROACH

The results are presented in detail in Chapter 2 of this report ("Overall Results"). Any breakdown of final demand can be applied to the model. We find it useful to look at the environmental impacts of household consumption activities. A breakdown of final household demand by COICOP is provided by the UK Office for National Statistics (ONS, 2003). The figures have been converted from purchasers' prices to basic prices by assuming the same ratio as for the total final demand by households.

The Ecological Footprint of service activities is relatively high because service industries are at the end of the value-added chain and require themselves a variety of resources from the secondary and primary sector, many of which have substantial Ecological Footprint.

Unlike other authors (Lenzen and Murray, 2001; McGregor et al., 2004) we do not endogenise capital investment into the input-output tables ('partial closure' of the input-output system). Instead we retain gross fixed capital formation as a final demand category thus allowing to demonstrate the impact of shared infrastructure (with construction being the largest receiver of capital investment).

A.2.4 CONCLUSION

Advantages of the method presented are:

- allocates the Ecological Footprint to detailed final demand categories, i.e. consumer responsibilities can be shown,
- can attribute the indirect, intermediate use of commodities to elements of final demand,
- uses standardised, official and annual statistics (provides a formal structure for Ecological Footprint calculations),
- permits sub-national, regional or local level Footprint estimates to be generated,
- permits the calculation of Ecological Footprints for different socio-economic groups,
- is suitable for policy scenarios.

A.3 Calculating the 'standardised' Ecological Footprint of Wales, Cardiff and Gwynedd

A.3.1 OUTLINE OF METHODOLOGY

The methodology employed in this project allows to calculate Ecological Footprints for any geographical sub-area of the UK including Wales and Local Authority (LA) areas like Cardiff and Gwynedd. The calculus is based on detailed household expenditure data by socio-economic group and LA area. It is important to mention that the resulting Ecological Footprint represents the impacts of *consumption* of the residents living in the respective area, i.e. it does not take into account the impacts of local industries!

Figure 29 shows an overview of the methodology on which the calculations are based. The 'top down' part is described in sections A.1 and A.2 (this section) and depicts the stages that are necessary to produce a 'standardised' Ecological Footprint for household consumption in any LA area of the UK. The 'bottom up' part is necessary to include locally specific consumption data that, if available, represent a more genuine picture of local consumption and replace the expenditure data used in the 'top-down' approach. This is described in the following sub-sections.

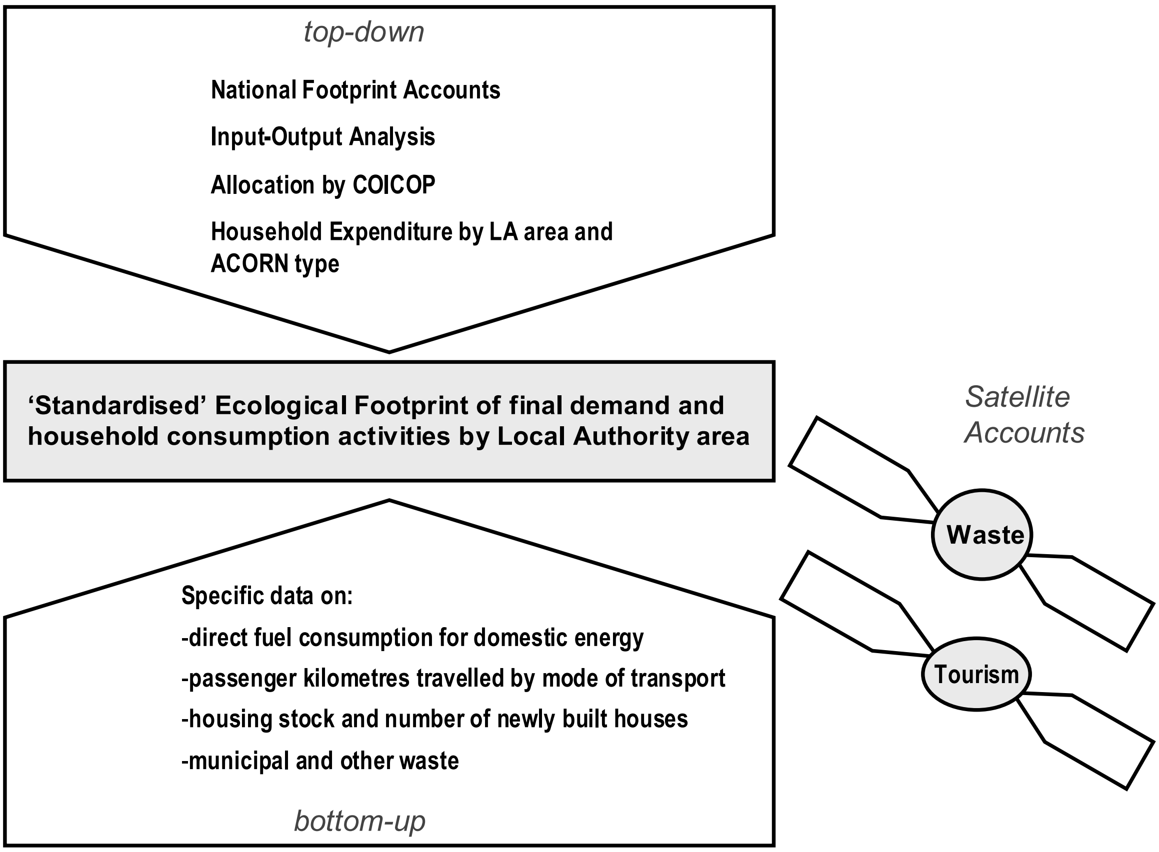

Figure 29: Outline of Ecological Footprint calculation methods employed in this project

A.3.2 SOCIO-ECONOMIC ANALYSIS OF HOUSEHOLD CONSUMPTION

The Stockholm Environment Institute at York (SEI) purchased data on expenditure on goods and services of socio-economic groups at Local Authority (LA) level. These data can be used to model local consumption of households. The source and nature of the data as well as SEI's employed methodology have been described below.

Description of data

Description of CACI

The data have been purchased from CACI. This marketing-data firm was founded in 1975 in the UK and employs in excess of 280 people, headquartered in London and located in three further offices around the UK, Coventry, Warrington and Edinburgh. CACI is a leading provider of consumer analysis and systems integration. Their micro-marketing and direct marketing area provides a combination of data, software and consultancy to help businesses market their products and services more effectively to the consumers.

Description of ACORN

The data provides a socio-economic breakdown by ACORN types. ACORN stands for "A Classification Of Residential Neighbourhoods." There are 1.7 million postcodes in the United Kingdom, the average postcode being shared by around 15 addresses. CACI has produced this classification to include every street in the country, fitting them into 17 distinct 'ACORN Groups', which, in turn, contain 55 'typical' ACORN neighbourhood categories (called 'ACORN Types').

ACORN profiles by postcode can be viewed in the Internet via this site: http://www.upmystreet.com.
The data reaches from ACORN Group 1 (Wealthy Achievers, Suburban Areas), Type 1 (Wealthy Suburbs, Large Detached Houses) to ACORN Group 17 (People in Multi-Ethnic, Low-Income Areas), Type 54 (Multi-Ethnic, High Unemployment, Overcrowding). Type 55 is 'Unclassified'.

The COICOP classification of consumption

COICOP is the "Classification of Individual Consumption According to Purpose". It is an international standard classification of types of individual expenditure, which breaks down household expenditure at the top level into twelve categories:

- 01 - Food and non-alcoholic beverages
- 02 - Alcoholic beverages, tobacco and narcotics
- 03 - Clothing and footwear
- 04 - Housing, water, electricity, gas and other fuels
- 05 - Furnishings, household equipment and routine household maintenance
- 06 - Health
- 07 - Transport
- 08 - Communication
- 09 - Recreation and culture
- 10 - Education
- 11 - Restaurants and hotels
- 12 - Miscellaneous goods and services

Each of these top level categories has two levels of further subdivision.
For example '03 - Clothing and Footwear' is subdivided as

03.1 - Clothing
03.2 - Footwear

And ‘03.1 - Clothing’ is then further subdivided as
03.1.1 - Clothing materials
03.1.2 - Garments
03.1.3 - Other articles of clothing and clothing accessories
03.1.4 - Cleaning, repair and hire of clothing

Full details can be found on the Internet at
http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5&Lg=1

How consumer spend estimates are created

Introduction

CACI’s local expenditure estimates provide robust patterns of consumer spending across a range of detailed retail and service categories, consistent with the latest Government national statistics. Future expenditure is projected for a broader range of product groups based upon long-term price trends and independent forecasts for macro-economic variables including Gross Domestic Product and Average Earnings. Both expenditure estimates and projections are available for a range of geographic levels including enumeration districts and postcode sectors.

Expenditure estimates

CACI produce estimates of current year spend split in 362 detailed ‘product categories’ ranging from ‘bread’ to ‘charitable donations’. These cover the entire spectrum of household expenditure, including services as well as goods, and correspond to 34 product groups defined using the European Union’s COICOP classification of consumer expenditure (see Table 76)[124].

CACI’s expenditure estimates are produced using the Office for National Statistics’ Household Final Consumption Expenditure figures, published in Consumer Trends (ONS, www.statistics.gov.uk). These provide control year totals for 34 individual product groups. The control year is normally about two years prior to the current year. CACI then use a combination of trend analysis and independent macro economic forecasts to project expenditure levels and prices in each product group to the current year. For the 362 detailed categories, local spend is derived through models which use Family Expenditure Survey spending relationships to quantify the propensity of individual households to buy items in each product group. These models are based upon predictor variables such as income, age, home tenure, presence of children, ACORN and regionality. CACI’s expenditure estimates are produced at enumeration district level (about 150 houses) for the UK and constrained in all cases to meet the constructed national control totals in Consumer Trends. The methodology for creating the consumer spend estimates is shown in the diagram below.

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124 From the year 2004 onwards, 83 product groups will be available.

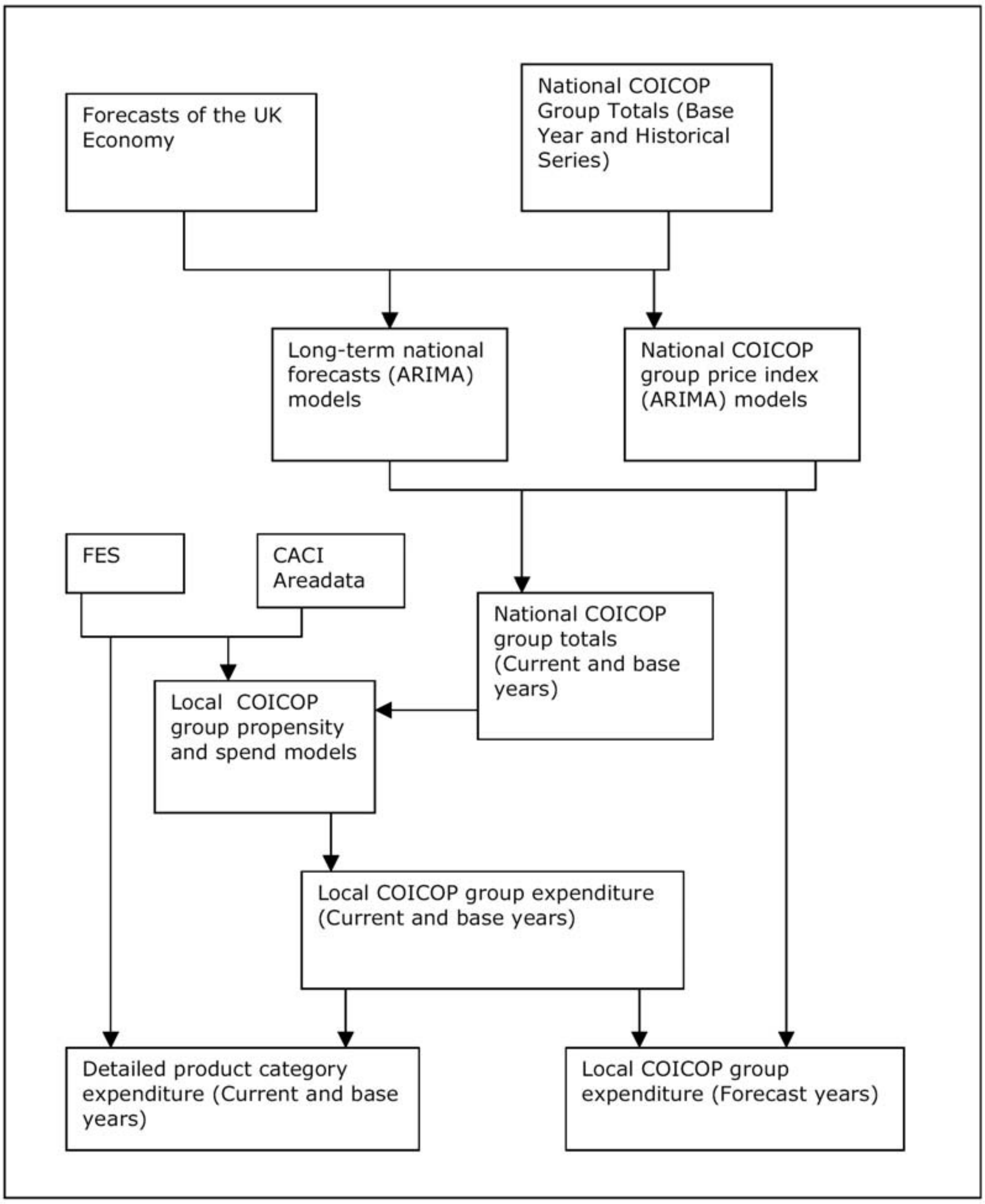

Figure 30: CACI methodology for creating consumer spend estimates (from CACI 2001)

The modelling process has two stages:

- Model the propensity of each household to purchase each product group.
- Estimate the amount which will be spent by the household if it does make the purchase.

Sets of statistical methods (Logosatic Regression) are used to model the propensity of individual households to buy items in a particular product group. This two stage modelling methodology is considered desirable because of its ability to effectively reflect behaviour in categories where a significant proportion of households have zero spend. This is particularly the case for spend on alcohol and tobacco.

CACI has used COICOP as the basis of the definition of product groups because it is emerging as a Europe-wide standard for expenditure classification. In particular all UK National Statistics products relating to household expenditure are converting to report using COICOP. The move is largely a result of COICOP being specified by the ESA95 European standard on national accounts to which all member nations are requested to conform.

There are two key benefits from use of COICOP:

- Estimates will be closely related to the National Statistics publication upon which they are based.
- There is a reasonable expectation, with adoption of COICOP as a national standard, of such estimates being directly comparable to estimates in other EU countries.

Model methodology using CACI data

Data used in the "Reducing Wales' Footprint" project

The first data set purchased for this project includes household and individual expenditure on 32 different product groups (see Table 76) by all 55 ACORN types. The second data set consists of the ACORN composition for every Local Authority (LA), i.e. the number of people in each of the 55 ACORN types per LA. The reference year is 2001.

Table 76: CACI product groups for which expenditure data were available on a LA level

CACI no.	COICOP no.	Product Group
0101	1.1	Food
0102	1.2	Non-Alcoholic Beverages
0201	2.1	Alcoholic Beverages
0202	2.2	Tobacco
0301	3.1	Clothing
0302	3.2	Footwear
0401	4.1, 4.2, 4.4	Actual and imputed rentals for housing, water supply and misc. dwelling services
0403	4.3	Maintenance and repair of dwelling
0405	4.5	Electricity, gas and other fuels
0501	5.1	Furniture, furnishings, carpets and other floor coverings
0502	5.2	Household textiles
0503	5.3	Household appliances (hardware)
0504	5.4	Glassware, tableware, household utensils
0505	5.5	Tools and equipment for house and garden
0506	5.6	Goods and services for routine household maintenance
0601	6.1	Medical products, appliances and equipment
0602	6.2, 6.3	Outpatient and hospital services (medical, dental, optical & nursing fees)
0701	7.1	Bicycles (purchase of vehicles)
0702	7.2	Operation of personal transport equipment
0703	7.3	Transport services
0801a	8.1a	Postal services (communications)
0801b	8.1b	Telephone and fax services (communications)
0901a	9.1a	Telephone and fax equipment (Audio-visual, photographic and information processing equipment)
0901b	9.1b	Audio-visual, photographic, computing equipment (Audio-visual, photographic and information processing equipment)
0902	9.2	Other major durables for recreation and culture
0903	9.3	Other recreational items and equipment; flowers, garden and pets
0904	9.4	Recreational and cultural services
0905	9.5	Newspapers, books and stationery
1001	10.1	Educational services
1101	11.1	Catering services

CACI no.	COICOP no.	Product Group
(1102)	(11.2, 9.6)	(Accommodation services, package holidays)
1201	12.1	Personal care
1203	12.3	Personal goods (personal effects n.e.c.)
(1204)	(12.4)	(Social protection)
(1205)	(12.5)	(Insurance)
(1206)	(12.6)	(Financial services n.e.c.)
(1207)	(12.7)	(Other services n.e.c.)
(3301)		(Spend outside the UK)

Notes: - No data was available for product groups in brackets ( ).
- CACI makes no estimate for COICOP category 12.4 (Social protection) and spend in this category is not included in any CACI estimate
- ONS make no estimates for COICOP categories 2.3 (Narcotics) and 12.2 (Prostitution).

Example: In Cardiff in 2001 there were 15,843 people who belong to ACORN Type 22 ("Academic Centres, Students and Young Professionals"). On UK average a person from ACORN Type 22 spent £18.58 per week on food in 2001 (COICOP 1.1).

Model method employed

From all data on 408 Local Authorities, 55 ACORN types and 32 product groups a datasheet with 718,080 single data points was created containing the information on total spending by each LA for each of the 32 categories.

Example: in Cardiff all people belonging to ACORN Type 22 spent a total of £294,335 per week on food.

From this, a total spending and an average spending per person per product group was calculated.

Example: all Cardiff residents spent £1,587,236 on food per week or £17.4 per person per week.

This calculation was performed for all 32 product groups and all 408 Local Authorities. The result is average spending per person per product group per LA, providing a very valuable information on consumption behaviour of the residents living in a LA area.

For further MFA and EF analyses a more detailed breakdown on products and services is useful. Therefore, a method was developed to disaggregate the 32 CACI product groups to the COICOP 3-digit level resulting in some 150 sub-groups of products and services. The ONS Household Expenditure Survey provides data on expenditure by the complete COICOP list by region (ONS, 2003c). Thus, the approach can be made directly comparable with the region or devolved government.

Example: From the ONS household expenditure it is known that in Wales 9.6% of the total expenditure on food is spend on COICOP category 1.1.1 "Bread, rice and cereals". The same proportion is used for Cardiff resulting on an expenditure of £1.67 on bread, rice and cereals per person per week (9.6% of £17.4).

In order to calculate the volume of consumption (in tonnes or g/cap/yr) average prices for products and services were used as conversion factors. These were available on a regional basis for food from the Expenditure and Food Survey (National Food Survey 2000, Chapter 2 therein). There are a couple of assumptions associated with these calculations:

- it is assumed that prices don't vary between LA areas, i.e. the average price for 1 litre of milk is the same within one region,

- the propensity to buy products of a certain price range is not taken into account, i.e. if ACORN Type 1 always buy more expensive products than for example Type 54, then this is not reflected in the data,
- it is assumed that each LA's expenditure pattern at the third COICOP level is the same as that of the region it is part of.

For products and services other than food no price information is available on a regional level (because the Household Expenditure Survey does not provide data in volume measures). In these cases regional consumption totals derived from PRODCOM were broken down to LA level by using expenditure as a direct proxy for proportion.

> *Example: All Cardiff residents together spent £463,303 per week on the product group 5.2 "Household textiles" whereas the entire population of Wales spent £7,657,901 per week. Cardiff's proportion on spending is 6.05% and therefore it is assumed that consumption (in volume measure) is 6.05% of the total Welsh consumption as well.*

The results of all calculations is a complete COICOP consumption profile in volume measures on a LA level (some 408 x 150 = 61,200 data points).

Evaluation of CACI data

General aspects

The data purchased from CACI are the most detailed information available on spending (and therefore consumption) behaviour of people living in a certain LA area. As it is notoriously difficult to get real, locally specific data the CACI data are almost invaluable for the purpose of MFA and EF on a sub-regional level. Some uncertainties remain as there had to be made assumptions on prices (see above). Solutions to this problem are sought for by co-operating with economic research institutes in the future.

The CACI data covers most of the COICOP list which provides a broad range across the whole spectrum of household consumption. It includes expenditure data on both products and services providing useful information if the impacts of a product-based consumption is to be compared to the impacts of a service-based economy. COICOP is also an international standard which will allow comparison between countries in the future.

Scientific rigour

A final assessment of the scientific credibility of the CACI can not be given as yet because of lack of detailed information. CACI is a marketing firm and not a scientific institute. To the knowledge of SEI there is no scientific, peer-reviewed publication of the methodology. However, CACI uses national statistics and databases from ONS as the source for their modelling and there is a decade long experience in economic modelling. The available description of the methodology makes a sound and reasonable impression. The fact that CACI are commissioned by ONS to undertake surveys suggests a certain degree of confidence in the data.

Representativity on a local level[125]

The ONS Family Expenditure Survey – on which the CACI model is based – is both regionally and geo-demographically representative. The data generated by CACI is all linked back to the UK census and the model variables have been updated using lifestyle data – of which CACI now hold over 24 million responses. The expenditure data are based on a sample size of 18.000 households, that have been surveyed over a three year time period.[126] CACI ensures that there is significant representation of the LA level (10's of 1000's).

Remaining data gaps

The CACI data represent the most comprehensive consumption related data available on a LA level. The level of detail on product consumption is sufficient for MFA and EF calculations. As of now some data on service consumption is missing (e.g. holiday spending, insurance spending, tax, etc.). A few specific issues are not covered. These include

- no distinction between conventional and organic food[127]
- no data on the origin of products (local/regional production versus imports)[128]
- no analysis of the different price paid for an item by different ACORN groups or types, e.g. ACORN Type 1 may spend twice as much on a toaster than someone from another ACORN Type.

The CACI data does not contain direct information on business or industrial activities. However, it includes data on spending on commercial and public services that again can be used as a proxy for material flows within the commercial and public sector.

The potential role of household surveys

The CACI data allow a reasonable accurate and representative estimation of consumption on a LA level. Apart from the data gaps mentioned above (organic produce and local production) the data are certainly sufficient to produce a locally specific Ecological Footprint.

However, a household survey can add valuable information to existing data if there is a specific interest in a certain product group, socio-economic group or in a certain policy scenario. In addition to questions about organic food and local purchasing, people could be asked about their future needs, expectations and hopes over the next 10-20 years in order to inform locally specific scenarios.

Taking into account the amount of time and resources to conduct a representative and reliable household survey and taking into account that both was limited within the scope of the project it was decided not to conduct surveys but to use the CACI data instead.

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125 Information from James Lennon (CACI).

126 James Lennon, CACI, personal communication

127 SEI does have data at the national level on organic food consumption, but not at the Local Authority level.

128 Supermarkets buy their products from the "UK market". Therefore, if Cardiff residents shop at supermarkets there will be no difference in the origin of products. A difference can only be made, if residents purchase substantial amounts of food from local Farmer's Markets.

A.3.3 SPECIFIC CALCULATIONS FOR FOOD

Ecological Footprints calculated according to the methodology presented above include all indirect impacts that are associated with the consumption of products, e.g. transport, distribution, packaging, etc.. In order to show these impacts explicitly and to provide a more detailed assessment of material flows and environmental impacts associated with the consumption of food, in-depth analyses of 49 food items including imports, transport and organic food were carried out. The basic methodology for these calculations is described in detail in the report to the project “Taking Stock – A Material Flow Analysis and Ecological Footprint of the South East” which is available on the website www.takingstock.org in the ‘Resource Pack’ area (there, food is under Chapter 3.4). Important details have been described below.

Food imports

Information on the proportions of each food item produced domestically and imported as well as the origin of those imports was compiled. The data used stem from three separate sources containing information on total UK production and the amount and origin of imports for each food item: the Survey on PRODucts of the European COMmunity (PRODCOM; ONS, 2001b), the DEFRA report Agriculture in the UK 2002 (DEFRA, 2002) and UK Trade Data, a set of data compiled annually by HM Customs and Excise (www.uktradeinfo.com), which lists total imports and exports to and from the UK. Information on the origin of imports was compiled on a world or region level rather than for individual countries. The regions used are Asia and Oceania, Eastern Europe, European Union, Middle East and North Africa, North America, Other America, Sub Saharan Africa and Western Europe.

Food transportation

The calculations consider all food transport up to the retailer, i.e. the supermarket or similar outlet. Basic unit is tonne kilometres (tkm) in order to account for both distance moved and weight of load. Total tonne kilometres for international transport up to the British border were calculated for each food item imported from the eight world regions mentioned above. Eight different modes of freight transport were taken into account: airplane, long distance shipping, short sea shipping, inland shipping, train, regular lorry, lorry with cooling system, delivery van. National distribution distances of the food products were estimated using the Office for National Statistics report Transport of Goods by Road in Great Britain 2001 (DETR, 2002). This report covers approximately 95% of all goods transported in the UK. Emissions for the different modes of freight transport were taken from the Energy Analysis Programme database (Wilting et al., 1999).

Embodied energy data for food products

The embodied energy content of all food products was divided into 2 parts: part 1 encompasses the energy required to produce the raw material (i.e. milk), while part 2 includes all energy required to process the raw material into the final product (i.e. cream). Data on the embodied energy of conventional produce in the Netherlands have been collected in the context of the Energy Analysis Program (Wilting et al., 1999). Since similar data are not available for the UK at present, those for the Netherlands had to be used instead. Calculating the according energy footprint is straightforward using the CO_2 sequestration method described in section A.2.4.

Organic food

The method for calculating MFA and EF for organic food is described in the food chapter of this project report (Chapter 3).

Reconciliation with the 'standardised' footprint

When calculating the Ecological Footprint with the 'top-down' and the 'bottom-up' approach, slightly different result are obtained due to the use of different input data, first and foremost embodied energy data. In order to present a consistent accounting framework the results were reconciled by recalibrating the total food footprint from the 'bottom-up' approach to the total food footprint obtained by the 'top-down' approach. Thus it is made sure that all results are consistent and comparable to those obtained in other 'standardised' footprint studies.

A.3.4 SPECIFIC CALCULATIONS FOR DOMESTIC ENERGY CONSUMPTION

Specific data on domestic gas consumption

One principle of the method employed is that locally specific, 'real' data shall be used whenever and wherever they are available and perceived to be more accurate and specific than household expenditure data. This is the case for data on consumption of natural gas. DTI publishes commercial and private gas consumption data per Local Authority area (DTI, 2001). The use of these data has various advantages as they are…

- … per LA area (and not per postcode area like other data sets),
- ... from an official government source (DTI),
- ... produced annually.

Therefore, the DTI data sets on gas consumption have been used to calculate the corresponding energy footprints of Wales, Cardiff and Gwynedd and the results have overwritten previously obtained results using the household expenditure model.[129]

The calculation of energy Footprints

During the course of the project there were discussions on the method with which the energy component of the Ecological Footprint is calculated. Therefore, a brief description of the method employed in this project follows. All calculations are consistent with the 'standard' calculations used in the National Footprint Accounts method (for the most recent publication of the method refer to Wackernagel et al., 2004).

The conversion method from CO_2 emissions to energy Footprint assume that all 'man-made' carbon dioxide, i.e. CO_2 emissions from the burning of fossil fuels, is being sequestered globally by the growth of biomass.[130] More precisely, the following steps are involved with the conversion:

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[129] Electricity and other energy consumption was modelled by using the expenditure data as described above.

[130] For a discussion on alternative possibilities to calculate the land need for fossil energy consumption (that all lead to similar results) refer to Stöglehner (2003).

8 convert the amount of CO_2 emitted in the equivalent amount of C,
9 apply the global average for C sequestration per ha of forest (0.95 t C/ha/yr; this approach uses IPCC data sources on forest timber productivity and forest carbon absorption),
10 convert hectares of forest to global hectares of global average productivity (equivalence factor 1.35 gha/ha),
11 take into account the percentage of CO_2 that is absorbed by oceans (= 31%).

With these four steps it is possible to convert any CO_2 emissions into global energy Footprints and vice versa. Please refer to section A.4 for calculations on CO_2.

A.3.5 SPECIFIC CALCULATIONS FOR PASSENGER TRANSPORT

'Standardised' transport footprints using passenger kilometre data

For passenger transport, locally specific data have been collected on kilometres travelled per person by different modes of transport in the year 2001. These data have been used instead of household expenditure data on private transport.

In order to be consistent with the 'standardised' footprint for passenger transport, results from the 'top-down' and the 'bottom-up' approach were reconciled. This was done on the UK level – for which reliable data from both approaches were available – by using the total 'standardised' transport footprint from the input-output approach and data on passenger kilometres for all modes on transport. The result is a set of 'standardised' footprint per passenger kilometre factors, shown in Table 77. These factors include indirect environmental impacts of transport as allocated by the input-output analysis. They were used to calculate the Ecological Footprints for passenger transport in Wales, Cardiff and Gwynedd.

Table 77: 'Standardised' Ecological Footprint factors per passenger kilometre travelled

Mode of travel	**Ecological Footprint per kilometre travelled** gha/cap/1000pkm
Airplane international	0.038
Airplane domestic	0.061
Walking (including short walks)	negligible
Bicycle	0.002
Private hire bus	0.043
Car (average occupancy)	0.056
Car (single occupancy)	0.088
Car (double occupancy)	0.044
Motorcycle/moped	0.056
Van/lorry	0.078
Other private	0.059
Local bus	0.043
Non-local bus	0.022
Surface Rail	0.022
Taxi/minicab	0.059
Ferry / small ship	0.033 [a)]
Other public (e.g. light rail, etc.)	0.035
Unknown	0.046 [b)]

a) estimated
b) simple average of all other modes of travel

Deducing passenger kilometre data

A detailed description of the method employed by SEI to calculate passenger kilometre data per Local Authority area can be found in the report "Ecological Footprint of North Lincolnshire and North East Lincolnshire" (Birch et al., 2004).

The transport statistics bulletin 2001 contains ACORN data under the categories of

- total passenger km's travelled per person per year
- the number of trips travelled by mode of transport per person per year for non car owners and car owners
- the number of trips travelled by destination per person per year for non-car owners and car owners.

This data was applied to ACORN data to provide estimates for passenger transport in each region. Four different methods were devised and as each was as credible as the others it was decided that an average should be taken of them all to produce the final figure.

Method 1: ACORN data was used to estimate the total distance travelled per person per year. This total was used to calculate the average distance travelled by each mode of transport using factors proportional to the values from the DTLR's Focus on Regional Transport (2001).

Method 2: The ACORN data within the Focus on Personal Transport report (DTLR, 2001) provided information on the total number of trips made by purpose of trip per person per year. This data was applied to the ACORN data to determine the regional breakdown. The categories included commuting, business and education, escort, shopping and personal business, and leisure. This data was then applied to the average length of a trip to each destination to produce a figure for total passenger kilometres.

Method 3: Data concerning the travel habits of people with and without cars was provided in the Focus on Personal Travel Report (DTLR, 2001). A breakdown of the number of trips by mode of transport for both car and non car owners was available. The number of trips was then multiplied by the average trip length to determine the UK number of passenger kilometres per person per year for each mode of transport. ACORN data concerning car ownership in Wales, Cardiff and Gwynedd were applied to those figures to determine the distance travelled by mode of transport for the average citizen of each region.

Method 4: Data concerning the travel habits of people with and without a car was used in the same manner as described in method 3 however this method used a breakdown under the category of trip purpose. The average trip length by purpose was supplied in the Focus on Personal Travel report (DTLR, 2001) and applied to the data.

The total distance travelled per person per year, as calculated in the four methods above, was averaged to determine a final answer for each region.

Recalibration: The ACORN proxy methods 1-4 were applied to all Local Authorities of Wales. The average of the total passenger kms of all LAs was higher than the total pkms for Wales. The reason for this is that the ACORN proxy method uses average UK distances and that the average distances travelled by Welsh residents is obviously lower (except from air travel, see below). Therefore, the

ACORN data results were recalibrated by applying the national (Wales) data from the National Travel Survey.

Air travel data

Data on air travel by Welsh passengers from 12 different airports in the UK were obtained from the Civil Aviation Authority Passenger Survey 2000/01 (supplied by Cardiff International Airport Ltd). The data represent passengers departing from these airports during 2000/01 with their 'ultimate origin' (i.e. residency) in Wales, Cardiff or Gwynedd, respectively. Data available for Wales as a whole comprised 16 Local Authorities (data for 4 northern LAs were not available). For this reason, the population of these 16 LAs was used to calculate the per person number.

For Wales, passenger data on the destination airport in the different destination countries were available, whereas for passengers from Cardiff only the destination country was known. Therefore, a proxy method for the Cardiff data was applied by assuming that destination airport numbers within a country were at the same proportion as for Wales passengers.

Distances between airports were calculated using OAG Max, a CD-ROM package containing an airport distance calculator. This was supplied to Cardiff University by OAG Worldwide on a one month free trial basis. Where this particular package did not include destination airports, distances were calculated using geographic distances between cities that were adjacent to destination airports. This was undertaken using the Geobytes City Distance tool (http://www.geobytes.com/CityDistanceTool.htm).

Passenger kilometres were calculated by multiplying passenger numbers with distances. These figures were then doubled in order to obtain return kms as passenger numbers refer to departures only. A distinction was made between domestic and international air travel.

For Gwynedd, data on five main airports used by Gwynedd residents were available (Birmingham, London Heathrow, London Gatwick, Manchester, Stansted). No data for Liverpool airport were available but it could be estimated that less than 10% of Gwynedd residents would use this airport.

A.3.6 SPECIFIC CALCULATIONS FOR HOUSING

Specific information on the housing stock and numbers of newly built houses in 2001 were available for Wales, Cardiff and Gwynedd. In order to enable scenarios about different types of homes, including energy and materials scenarios, the ‘standardised’ footprint for housing (COICOP categories ‘Actual rentals for housing’, ‘Imputed rentals for housing’ and ‘Maintenance and repair of the dwelling’) was link with the locally specific data and Ecological Footprints of different types of homes. The calculation of the latter is described in detail in the report "Sustainability Rating for Homes – The Ecological Footprint Component" (Wiedmann et al., 2003). Again, results from ‘top-down’ and ‘bottom-up’ approach were reconciled by constraining them to add up to the ‘standardised’ UK total footprint for housing.

A.3.7 SATELLITE ACCOUNT: WASTE

Calculating the Ecological Footprint for waste

The Ecological Footprint for waste is not included in the 'standardised' footprint calculations but is treated as a satellite account instead. The reason for this is because the impacts of household consumption can only be counted once, either at the 'input' side, when products are bought or consumed, or at the 'output' side, when these products are discarded. The method describe above looks at the environmental impacts of consumables and therefore it would be double counting if the impact of waste from these consumables were just added on.

For specific analyses however, it is useful to look at the impacts of waste separately. For example, this allows to explore and compare different waste management technologies. Therefore, the Ecological Footprint of waste has been calculated separately as a satellite account, i.e. the results are 'stand alone numbers' that exist in parallel to the 'standardised' footprint and must not be added to any of the other results. An exception was made for waste recycling because some of the adverse impacts of consumption can be alleviated through the recycling of materials after their use. Therefore, credits to the footprint were given for waste recycling (see below). All results for waste in Wales are presented in Chapter 7 of this report.

The methodology of calculating the satellite waste footprint is described in detail in the report to the project "Taking Stock – A Material Flow Analysis and Ecological Footprint of the South East" which is available on the website www.takingstock.org in the 'Resource Pack' area. The document has been separated into individual chapters for ease of use and downloading; the document about waste is Chapter 4 "Material Flow Analysis and Ecological Footprint of Waste in the South East"[131].

The method was used to calculate the waste Footprint for Wales, Cardiff and Gwynedd. The data sources used are compiled in the Appendix of Chapter 7 (Waste). Most of the relevant reports can be found on this website: http://www.walesregionalwasteplans.gov.uk.

Credits for waste recycling

The reductions to the Ecological Footprint through waste recycling (credits) are then subtracted from the total 'standardised' footprint.

A.3.8 SATELLITE ACCOUNT: TOURISM

Top-down approach

One of the columns in the final demand part of the economic use table provided annually by ONS (see section A.1) is titled "Non-resident household expenditure in UK". This is part of the households final consumption expenditure by COICOP and shows the annual expenditure of overseas visitors in the UK, including all purposes of visits like holiday, visiting friends and relatives and business.

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[131] The document is not available in hard copy but if you are unable to download the report, please contact Leonie Simpson from EcoSys Environmental Management and Education, Level 7 (South), New England House Business Centre, New England Street, Brighton BN1 4GH, Phone: 01273 245 587, Fax: 01273 245 516, Email: feedback@takingstock.org.

This information can be used to estimate the average Ecological Footprint of a overseas visitors reflecting the environmental impact during the length of their stay. In the input-output analysis the column on non-resident expenditure is treated like any other column on household expenditure with the exception that the resulting total footprint of 5 million gha is not divided by the number of UK population. Instead the corresponding number for overseas 'visitor years' is used to derive a per person figure. Total visitor years are calculated by multiplying the total number of visitors in one year with the average length of their stay. This number (reflecting the notion of how many visitors there were if they all stayed for one year) is directly comparable with the population of a given country (implicitly assuming that all residents stay in the country for the whole year).

The result is a per person figure of 9.8 gha/person. This suggests that the impact of a visitors 'lifestyle' is almost twice as much as that of a UK resident for which the Ecological Footprint is 5.35 gha/cap. The reason for this significant difference has most likely to do with the fact that tourists – whilst they are staying in their country of destination – tend to consume more services and travel more than residents.

Bottom-up approach

Locally specific data on visitors can be used to calculate a more specific footprint of tourists that stay in a certain area. Provided a sufficient availability of data, this can be done by working out a typical consumption profile of tourists in the area. For example, if the amount of waste is known that does not come from residents then a waste per visitor number can be established. The resulting consumption data are then simply subject to the same Ecological Footprint calculations as described above.

A.4 Calculating Carbon Dioxide Emissions

Sometimes, the Ecological Footprint concept seems to be misinterpreted in the way that it would strictly not allow any increase of greenhouse gas concentrations in the atmosphere, i.e. that humanity should return to the pre-industrial state of CO_2 concentrations. This is wrong. The notion of energy Footprints is rather to set a standard by which, when eventually achieved, carbon dioxide concentration will not *continue* to increase, i.e. no *further* accumulation in the atmosphere would take place (see also Ferguson, 2001). The difference is subtle but important.

Section A.3.4 on page A-182 describes how the energy Footprint is calculated from CO_2 emissions. It is possible to reverse this calculation and derive CO_2 emissions from energy Footprints. However, only the 'fossil fuel CO_2 energy Footprint' is associated with actual CO_2 emissions, not the 'nuclear CO_2 energy Footprint' (see Wackernagel et al. 2004, page 17).

The fossil fuel energy Footprint was taken from the National Footprint Accounts (Moran, 2004). The National Footprint Accounts use the IPCC sectoral approach to account for CO_2 emissions (emissions from actually combusted fuels). They then add a "World Bunker Fuel Burden" that is supposed to represent the actual use of bunker fuels. CO_2 emissions embodied in imports and exports are estimated by using embodied energy figures for goods. The uncertainty with these embodied emissions is relatively high.

The fossil fuel energy Footprint for Wales was calculated by using expenditure data and real fuel consumption data as described above. Then the CO_2 emissions corresponding to these fossil fuel energy Footprints have been calculated using the four steps described section A.3.4 on page A-182.

The resulting CO_2 emissions are those for which the consumer is responsible, because they include embodied CO_2 emissions from imported goods. **For a discussion about responsibility for CO_2 emissions please refer to Chapter 2 of this report ("Overall Results").** The 'consumer responsibility' CO_2 emissions can be compared with the territorial emissions. The results of this comparison are described in Chapter 3 ("Overall Results").

Data source for territorial emissions in the UK (= 606 Mt of CO_2 in 2000):
ONS, 2004. Environmental Accounts: Emissions; Greenhouse gases, 93 economic sectors, 1990-2002, revised 2004. Office for National Statistics, London. Table download at:
http://www.statistics.gov.uk/statbase/Publication.ASP?to=1&su=30&B3.x=23&B3.y=14

Data source for territorial emissions in Wales (= 42.1 Mt of CO_2 in 2000):
Key Statistics for Wales;
http://www.wales.gov.uk/keypubstatisticsforwales/content/publication/environment/2004/sb8-2004/sb8-2004.pdf

Data source for population in the UK and Wales:
ONS, 2003e. Statbase Datasets. Revised UK population 2000. Office for National Statistics, London. Table download at: www.statistics.gov.uk/popest
www.statistics.gov.uk/popest

Data source for UK energy Footprint from fossil fuels (= 3.02 gha/cap): Moran, 2004

A.5 Analysing Material Flows for Wales – Regional MFA

A.5.1 PRODUCTION OF MATERIALS

The main database that is employed is PRODCOM (classified by the Standard Industrial Classification, SIC). From this, data concerning the actual consumption of each material/product can be derived. The term PRODCOM is derived from PRODucts of the European COMmunity. This is a survey based on products whose definitions are standardised across the EC to allow comparability between the member countries' data. The PRODCOM annual reports (PRA) contain data on UK sales, imports and exports in both value and volume measure[132]. PRODCOM covers some 4,800 products that in the UK are assigned to some 250 industries (subclasses) as defined by the 1992 Standard Industrial Classification SIC(92) and is available from the Office for National Statistics.

In order to allocate the production by region for each commodity two different methods where used. The transport model and a specific data model. The transport model is based on transport data for each region (DfT, 2003). The production by region was based on the amount of goods that where lifted by UK region by Heavy Good Vehicles (HGV's) in thousand of tonnes. The data is available for imports, exports and production minus imports for each region. The good lifted data was divided into 99 categories and these were allocated to the relevant PRODCOM category. For each dataset the regions allocation was based on the amount of good lifted per region and then given in % figures for each regions making sure that the total percentage adds up to 100% for each product category. Finally the total amount of production for each product was multiplied by the percentage of production for each region to get a complete regional allocation model for transport. The 'specific data model' uses real data from Wales wherever they were available (e.g. Aggregate Minerals Survey for England and Wales, BGS, 2003).

A.5.2 CONSUMPTION OF MATERIALS

In order to calculate the direct and indirect material flows (MF) of consumption in Wales the same method as for the Ecological Footprint was employed. Direct MF intensity multipliers were calculated from the production volumes of each industry in the UK and total MF intensity multipliers were derived by postmultiplying with the total requirement matrix (see section A.1.2). This results in MF of final demand in the UK.

The same expenditure model was then employed to derive MF of consumption in Wales (see section A.2.2). Due to data and time constraints, the material flows for government infrastructure and business/industry infrastructure were calculated pro rata from UK data, i.e. they are proportional to population. Therefore, we have not calculated the impact of the Welsh Assembly Government, but have included it with the impact of national government. Implicitly, this procedure assumes that the responsibility for public and industrial infrastructure is shared equally amongst the population of the UK.

132 PRODucts of the European COMmunity (PRODCOM), PRODCOM Annual Industry Reports 2000, Office for National Statistics, http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=9660&Pos=1&ColRank=1&Rank=256

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Reports published by the project include 'Reducing Wales' Ecological Footprint. A resource accounting tool for sustainable consumption'; 'Reducing Cardiff's Ecological Footprint. A resource accounting tool for sustainable consumption'; 'Reducing Gwynedd's Ecological Footprint. A resource accounting tool for sustainable consumption' and a summary of the main findings. For further information visit **www.walesfootprint.org**

Biffaward Programme on Sustainable Resource Use

This report forms part of the Biffaward Programme on Sustainable Resource Use. The aim of this programme is to provide accessible, well-researched information about the flows of different resources through the UK economy based either singly, or on a combination of regions, material streams or industry sectors.

Information about material resource flows through the UK economy is of fundamental importance to the cost-effective management of resource flows, especially at the stage when the resources become 'waste'.

In order to maximise the Programme's full potential, data will be generated and classified in ways that are both consistent with each other, and with the methodologies of the other generators of resource flow/ waste management data.In addition to the projects having their own means of dissemination to their own constituencies, their data and information will be gathered together in a common format to facilitate policy making at corporate, regional and national levels.

More than 30 different mass balance projects have been funded by Biffaward. For more information on the Mass Balance UK programme please visit **www.massbalance.org**

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