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The greenhouse gas footprint of Cumbria

Managing the greenhouse gas emissions from Cumbria's residents, visitors and industries

September 2012

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1 Executive summary

1.1 Local action on climate change

There is a strong scientific consensus that emissions of carbon dioxide and other greenhouse gases[i] need to peak and then decline sharply over the next twenty years, in order to avoid dangerous climate change.[ii] The UK has a target, enshrined in law, to reduce carbon emissions by 80% by 2050, and at least 34% by 2020. Significant carbon reductions will be achieved through European and national policy, but local areas will also need to act in order to meet these targets. New guidance by the Local Government Association[iii] sets out how local areas can contribute, and over fifty local councils have announced their commitment to this process.

Actions to cut carbon can have considerable benefits over and above the carbon saving. These include: greater business efficiency and reduced energy bills for householders; development of a low-carbon industrial sector; benefits to tourism including promoting local, seasonal food and better public transport for visitors and residents.

This report, commissioned by the Cumbria Chief Executives Group, aims to help Cumbria, as a county, measure and manage its carbon emissions, so that it can contribute to national carbon reduction efforts and reap the benefits of a low-carbon economy and society.

1.2 Benefits of consumption based carbon reporting

Consumption based carbon reporting includes emissions that take place in the supply chains of goods and services, wherever in the world those emissions take place. For a local area, this can be used to map out the climate change impacts of the lives of residents, including everything they buy and do, as well as the full impact of businesses up to the point of delivery of goods and services. Reporting in this way identifies important areas for carbon management that are not reached through energy management alone, including food, purchased goods, and tourism. In doing so, consumption based reporting directs attention to new policy opportunities where the potential for co-benefits may be greater and more diverse than the cost savings that may be achieved through direct energy savings alone.

In April the House of Commons Energy and Climate Change Committee inquiry into consumption based reporting[iv] concluded that the UK should adopt consumption based metrics in order to report on the emissions embodied in overseas trade. It also drew strongly on case studies of policy applications of local authorities, including the Lake District, adopting the same approach.

1.3 Results

This report provides a comprehensive 'map' of carbon emissions in Cumbria. It uses a consumption-based approach, as explained above. It measures emissions from Cumbria's residents, and also the emissions of visitors to the County, including the carbon emissions caused by visitors getting to and from Cumbria.

The chart below sets out the overall picture of carbon emissions. The blue section shows emissions from residents of the County; the green section is emissions from visitors while in Cumbria; and the red section shows the carbon emissions of visitors travelling to and from Cumbria.

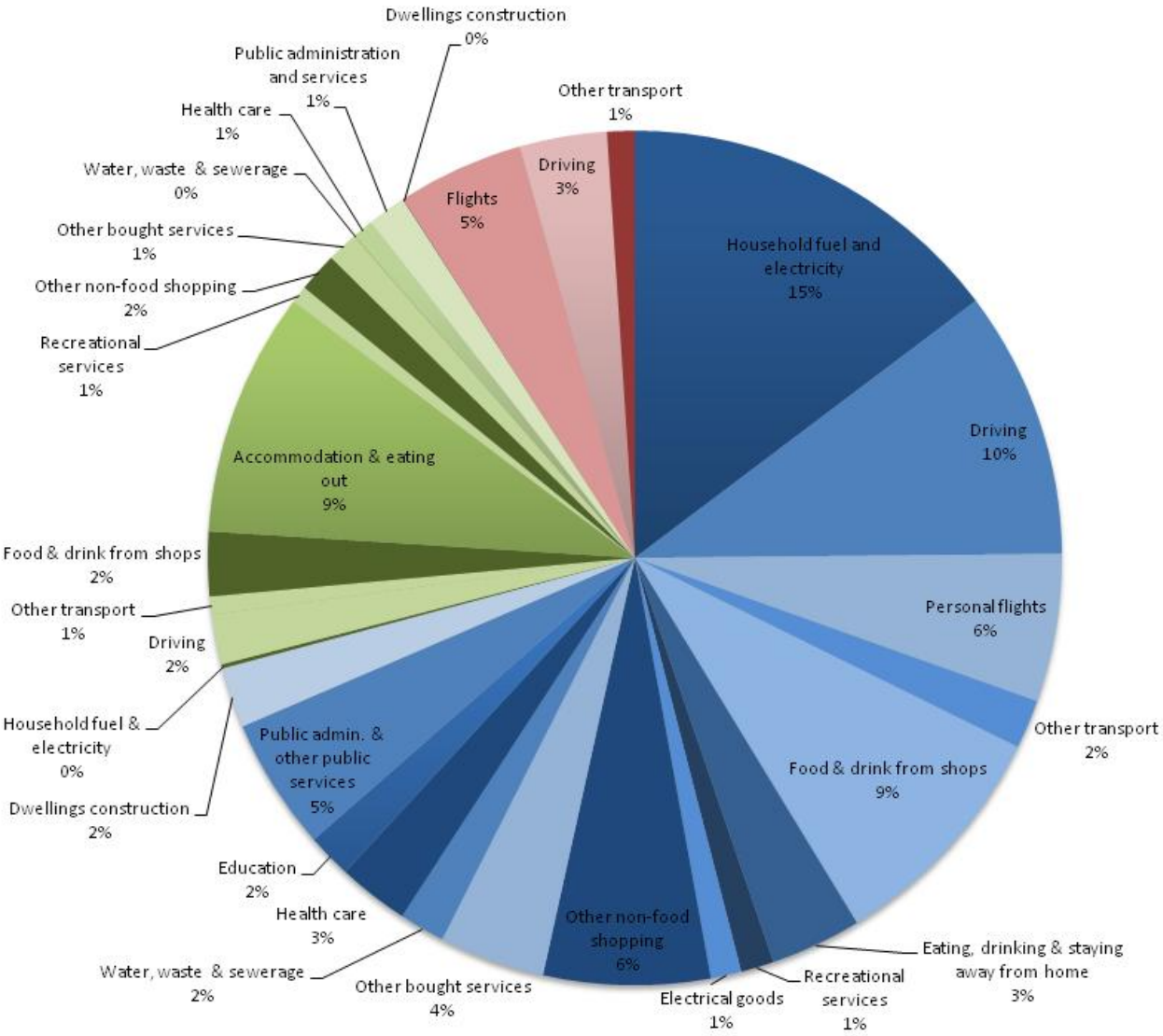

Figure 1: The total footprint of Cumbria's residents and visitors; 11 million tonnes CO_2e. (Blue: residents; Green: visitors; Red: visitors getting there and away)

The main points to note are:

- The total emissions, by residents and visitors combined, are estimated at around 11 million tonnes CO_2e per annum.

- Residents account for 71% of this (7.8 million tonnes CO_2e), which equates to approximately 15.73 tonnes CO_2e per annum per capita. This is close to our estimate of the average UK person's footprint of 16.3 tonnes CO_2e per capita.
- Visitors consumption of goods and services, and their use of personal and public transport during their stay accounts for 20% (2.2 million tonnes CO_2e). In addition visitor travel there and away accounts for a further 9% of the total (1 million tonnes CO_2e) meaning overall visitors have a footprint of roughly 418 kg CO_2e per visitor day[1], including getting there and away.

Taking residents and visitors together, the largest categories of emissions (in other words, the most significant source of carbon emissions) are as follows:

- Domestic energy use, i.e. heating, lighting and electricity use in households, which accounts for 15% of the total
- Driving by residents (10% of the total)
- Food bought from shops, by Cumbria residents (9% of the total)
- Visitor accommodation, and eating out (9% of the total)
- Other, non-food shopping, by Cumbria residents (6% of the total)
- Flights by Cumbria residents, e.g. flying to a holiday destination, excluding business flights (6% of the total)
- Visitors flying to get to and from Cumbria: 5%

The figure below shows this information graphically, highlighting the significance of three key areas: driving, accommodation for residents and visitors alike, and food.

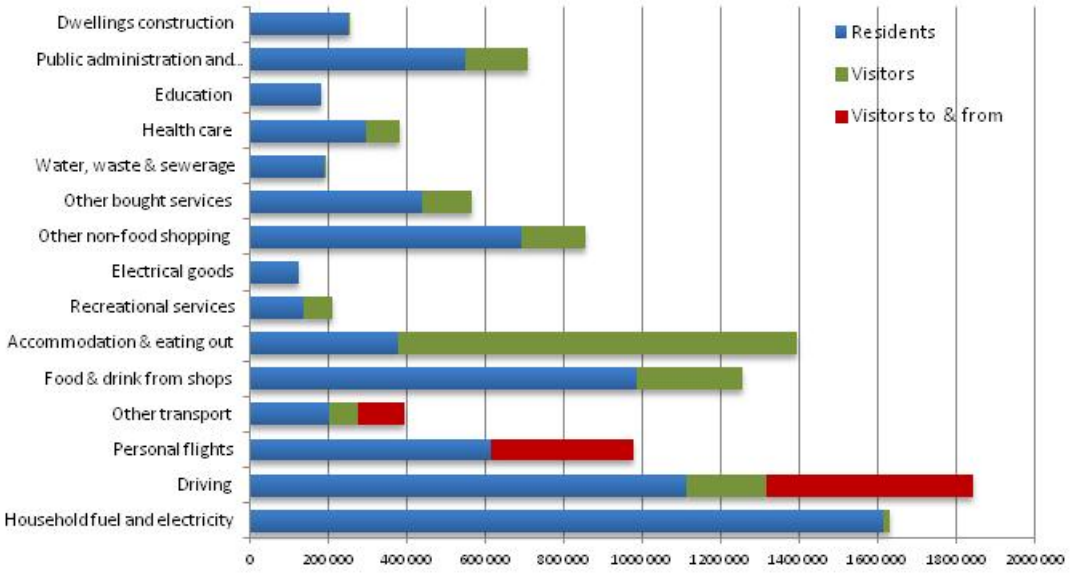

Figure 2: Cumulative totals of resident and visitor emissions by emissions source (tonnes CO_2e) (Blue: residents; Green: visitors; Red: visitors there and away)

[1] Based on STEAM 2010 estimates for number of visitor days. Source: Cumbria Tourism (2010).

1.4 Variations in carbon emissions across the different Districts

There is some variation between residents of the different Districts, with Eden having the lowest *per capita* footprint at 14.6 tonnes CO_2e per year and Copeland, the highest, at 16.6 tonnes CO_2e per year. There are also differences between Districts in the profile of these emissions. For example while Allerdale's residents have higher than average consumption of household fuels and electricity their consumption of goods and services are amongst the lowest in the County. Section 3 below discusses the differences between the different Districts within Cumbria.

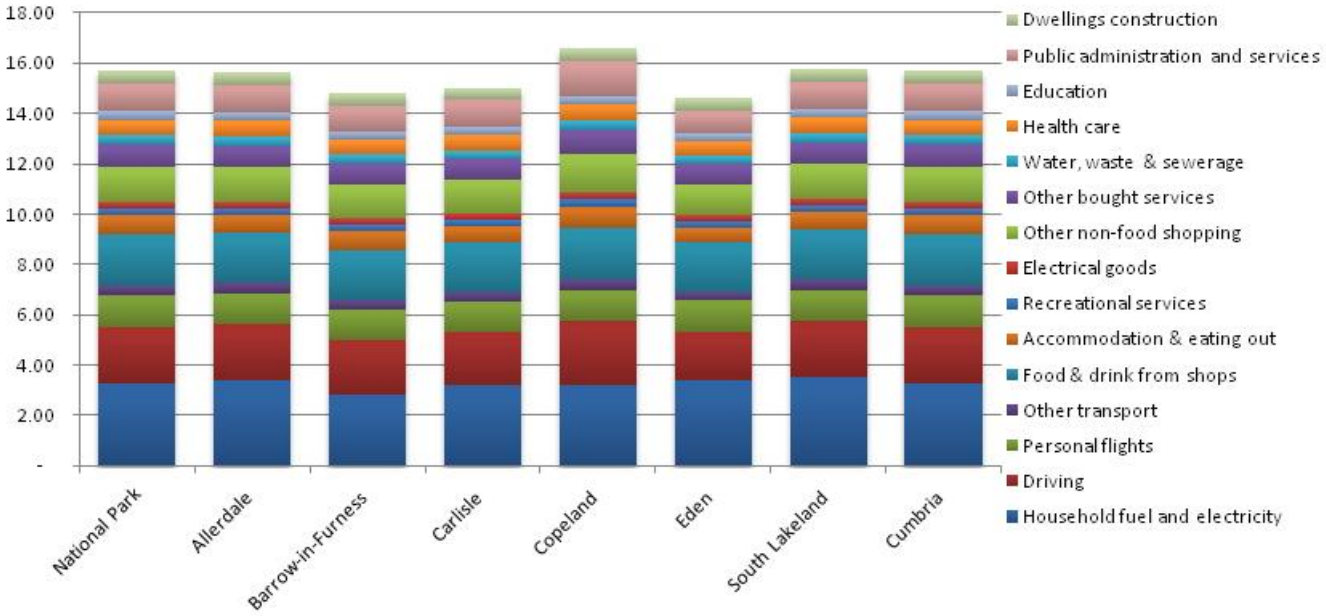

Figure 3: Breakdown of per capita emissions by District and source of emissions (tonnes CO2e)

1.5 The carbon footprint of Cumbrian industry

The carbon footprint of all Cumbria industries is estimated at 15.7 million tonnes CO_2e. This figure includes direct emissions, emissions from electricity consumption and indirect emissions in the supply chains. The main points to note are:

- Manufacturing is responsible for the biggest share of emissions, both direct emissions from manufacturing processes and indirect emissions from the supply chain.
- Emissions from agriculture, forestry and fishing, which account for nearly 7% of the total footprint of industry, mainly occur on the farm. Other sources of emissions include the production of feed and fertiliser. Though the science of emissions from this sector is very complex, there are some simple measures that can be implemented to reduce emissions, and these are set out in Section 4.
- Across all industry, there are considerable carbon savings to be gained from looking at procurement in supply chains, in addition to direct energy use. Often there are significant cost savings as well as carbon savings.

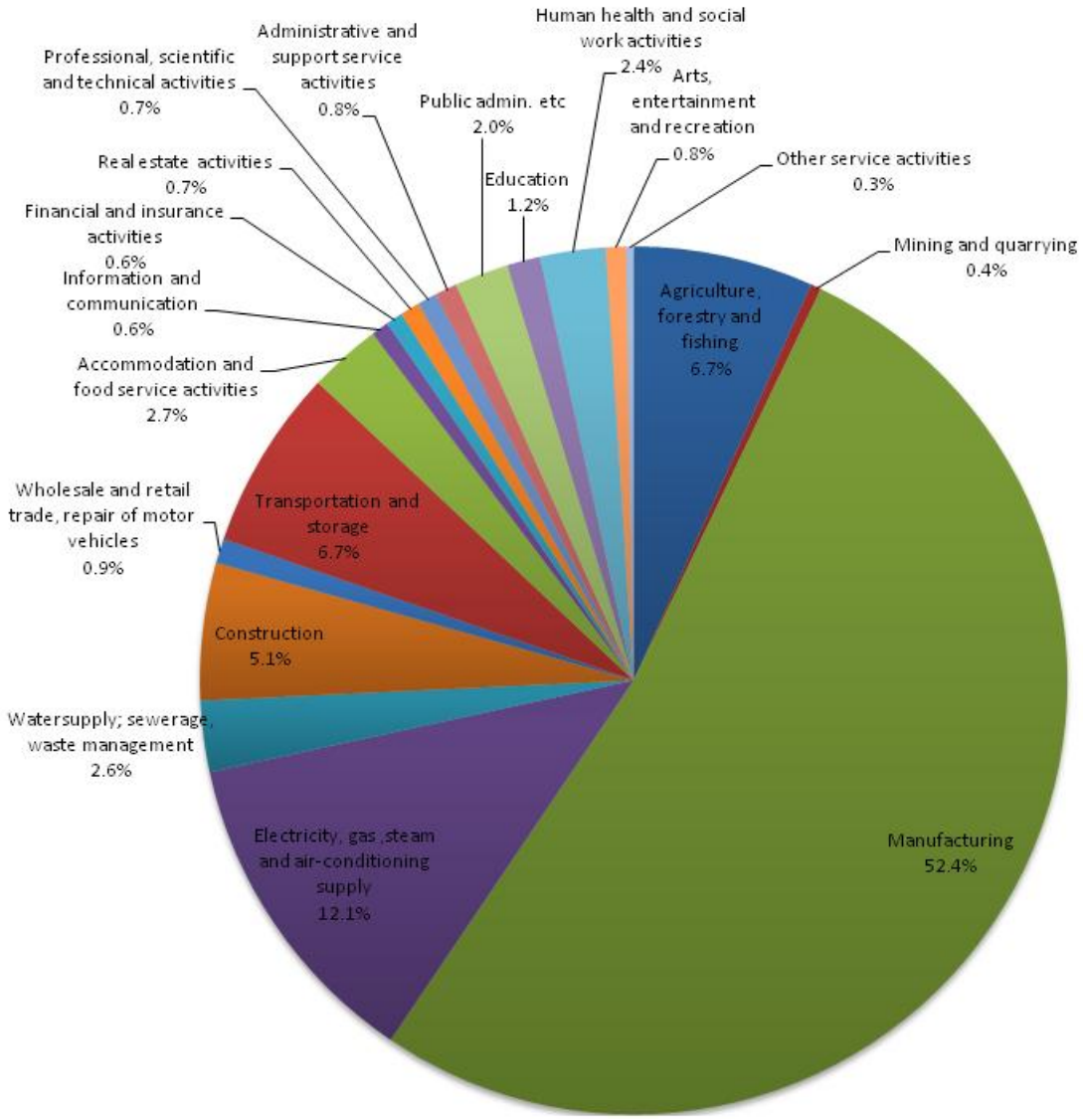

Figure 4: Breakdown of the carbon footprint of Cumbria's industry by sector; 15.7 million tonnes CO2e

1.6 Recommendations

The findings above show the most significant sources of carbon emissions in Cumbria. This can be used to inform decisions about carbon reduction strategies.

Information about emissions should be combined with other criteria, such as economic and social benefits. The criteria for prioritising projects should include of the following:

- Likely carbon savings
- Economic costs and benefits of the action, in the short and longer term (some actions may require investment but will result in savings over the medium to long term)
- Social costs and benefits, with a particular focus on distributional effects

- Organisational strategy and priorities of each organisation within the Cumbria Chief Executives Group, as well as priorities of the Group as a whole
- The fit with national and EU policy and objectives, such as the Government's new Green Deal which will fund energy efficiency investment; the strategy for renewable energy, and so on
- The availability of funding or investment, from public, commercial or charitable sources

Based on these criteria, our initial recommendations for priority areas are as follows:

Building energy-use: This area is associated with significant emissions as well as costs for businesses and households. It fits with the Government's Green Deal proposals.

Travel: Finding ways to reduce the need to travel, and to improve efficiency of travel, has multiple benefits. There is potential to save residents money and time, and to improve the quality of the visitor experience, whilst diverting visitor spend into the local Economy. The GoLakes Travel project in the Central Lake District is an example of action in this area.

Repair, recycle and resale: Given the considerable significance of non-food shopping, any increase in repair, recycling and resale of consumer goods will bring about carbon savings. Focussing on developing these industries has potential to boost the local economy whilst reducing costs for households and businesses. Other local areas, including West Sussex, have been pioneering this approach.

Food: Focussing in particular on reducing waste and shifting towards lower carbon diets has potential to simultaneously improve health, wealth and wellbeing for residents and visitors. Local food also benefits the local economy.

Tourism: There is scope to enhance visitor experience and the economic benefits through encouraging tourism providers to improve their environmental performance. More efficient buildings, sourcing of local, seasonal food and drink, and promoting non-car transport are all important. If domestic tourism and longer stays are encouraged, there are clear economic benefits, and carbon is reduced too, as travel becomes a smaller component of both carbon and financial cost of the trip.

2 Introduction

2.1 Local action on climate change

There is a strong scientific consensus that emissions of carbon dioxide and other greenhouse gasesv need to peak and then decline sharply over the next twenty years, in order to avoid dangerous climate change.vi This means that developed countries like the UK must reduce carbon emissions significantly. The UK has set itself a target, or 'carbon budget', enshrined in law, to reduce carbon by 80% (from a 1990 baseline) by 2050, and at least 34% by 2020. The independent Committee on Climate Change monitors progress and advises on strategies to meet this target.

Some of this budget can be met through policy and incentives put into place by national government and the EU. Electricity can be decarbonised through greater use of renewable energy, carbon capture and nuclear power; tougher vehicle standards can be introduced; the EU carbon trading scheme puts a price on carbon emissions and incentivises reduction.

Local areas will also need to act in order to meet this budget. Local areas need to put the right incentives, infrastructure and advice in place, to enable everyone to play their part in reducing carbon emissions. A recent report by the Committee on Climate Change[vii] (CCC) recommended a stronger role for Local Authorities in meeting statutory carbon targets, and stresses that these targets will only be met through action at local level as well as national initiatives. The CCC has recommended that local government should be required to produce a low-carbon plan, and adequate resources to fund the work. Meanwhile, the Local Government Association has launched the 'Climate Local' initiative[viii], which encourages all local councils to develop a strategic approach to reduce carbon emissions and increase resilience to the anticipated changes in the climate. This follows on from the 'Nottingham Declaration' on climate change. Over fifty Councils have signed up to the initiative to date.

Actions to cut carbon can have considerable benefits over and above the carbon saving. These include: greater business efficiency and reduced energy bills for householders; development of a low-carbon industrial sector; benefits to tourism including promoting local, seasonal food and better public transport for visitors and residents.

2.2 Benefits of consumption based carbon reporting

Consumption based carbon reporting includes emissions that take place in the supply chains of goods and services, wherever in the world those emissions take place. For a local area, this can be used to map out the climate change impacts of the lives of residents, including everything they buy and do, as well as the full impact of businesses up to the point of delivery of goods and services. This opens up important areas carbon management that are not reached through energy management alone. These include food, purchased goods, and tourism. In doing so, consumption based reporting directs attention to new policy opportunities where the potential for co-benefits may be greater and more diverse than the cost savings that may be achieved through direct energy savings alone.

In April the House of Commons Energy and Climate Change Committee inquiry into consumption based reporting[ix] concluded that the UK should adopt consumption based metrics in order to report on the emissions embodied in overseas trade. It also drew strongly on case studies of policy applications of local authorities, including the Lake District, adopting the same approach.

2.3 This report

This project was commissioned by the Cumbria Chief Executives Group and presents the first estimate of the consumption-based greenhouse gas emissions (GHGs) generated from the products and services that are consumed within the County.

We use the term 'footprint' to mean the emissions resulting directly and indirectly from consumption of goods and services within Cumbria, and resulting directly and indirectly from travel to, from and within the County.

The report sets out the following:

- the total carbon footprint of Cumbria's residents, visitors and industries,
- a breakdown of the main sources of emissions at County level and for each of the six Districts along with the Lake District National Park.

The assessment follows the reporting principles of the GGP published by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI).

We therefore cover all the gases specified in the Greenhouse Gas Protocol (GGP) expressed in terms of carbon dioxide equivalent (CO_2e), the sum of the weights of each gas emitted multiplied by their global warming potential (GWP) relative to carbon dioxide over a 100 year period.

2.4 Consumption based carbon footprints

This report takes a consumption based approach. This means that supply chain emissions associated with the production of goods and services consumed by residents and visitors are included wherever those emissions actually take place. For example, emissions from the production and transport of foods eaten in Cumbria lie within the scope, whereas the 'footprint' of food produced within Cumbria but exported is not included in this analysis. To give another example, in a consumption based analysis, the carbon footprint of driving includes not only the direct emissions from the burning of fuel but also emissions resulting from the extraction, shipping and refining of the fuel, as well as a component for the manufacture of the vehicle itself. The adoption of a consumption based approach is particularly important when seeking to understand and manage the impacts of lifestyles and of service economies, since in these cases, supply chain emissions often dwarf the direct emissions that would be included in an assessment of only direct emissions.

2.5 What is included and what is not

The assessment includes emissions resulting from everything residents do and buy in their personal lives and everything that visitors do and buy during their stay within the County, as well as their travel there and away. More specifically, the following is within the scope of this assessment:

- all residents personal travel and visitor travel to, from and around Cumbria,
- fuel and electricity consumed in homes and places to stay,
- emissions from food and drink and other purchases,
- emissions resulting from the use of services, including public services,
- the supply chains of all the above (e.g. fuel supply chains and embodied emissions).

The emissions resulting from Cumbria's businesses and industry (excluding business travel) are included separately to enable the effective targeting of carbon management activities.

3 The carbon footprint of residents and visitors

3.1 Overview

Emissions resulting from consumption of goods and services by Cumbrian residents and visitors combined are estimated at around 11 million tonnes CO_2e per annum. 71% of this (7.8 million tonnes CO_2e) is generated by resident consumption, which equates to approximately 15.73 tonnes CO_2e per annum per capita. This is close to our estimate of the average UK person's footprint of 16.3 tonnes CO_2e per capita.

Visitors consumption of goods and services, and their use of personal and public transport during their stay accounts for 20% (2.2 million tonnes CO_2e). In addition visitor travel there and away accounts for a further 9% of the total (1 million tonnes CO_2e) meaning overall visitors have a footprint of roughly 418 kg CO_2e per visitor day[2], including getting there and away.

Taking residents and visitors together, 60% of the total footprint falls into the seven largest categories as follows:

- Residents domestic energy: 15%
- Residents driving accounts: 10%
- Residents food bought from shops: 9%
- Visitors accommodation and eating out: 9%
- Residents other shopping: 6%
- Residents personal flights: 6%
- Visitors flying to get to and from Cumbria: 5%

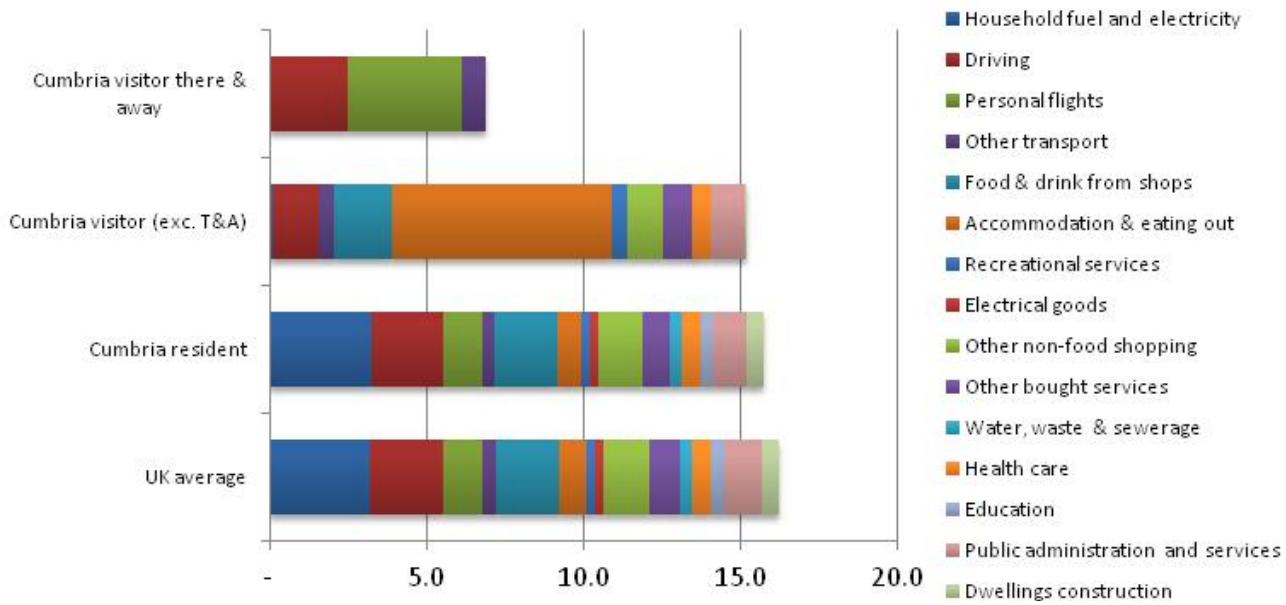

Figure 5: Comparison of *per capita* emissions of residents and visitors against UK average (tonnes CO_2e)

[2] Based on STEAM 2010 estimates for number of visitor days. Source: Cumbria Tourism (2010).

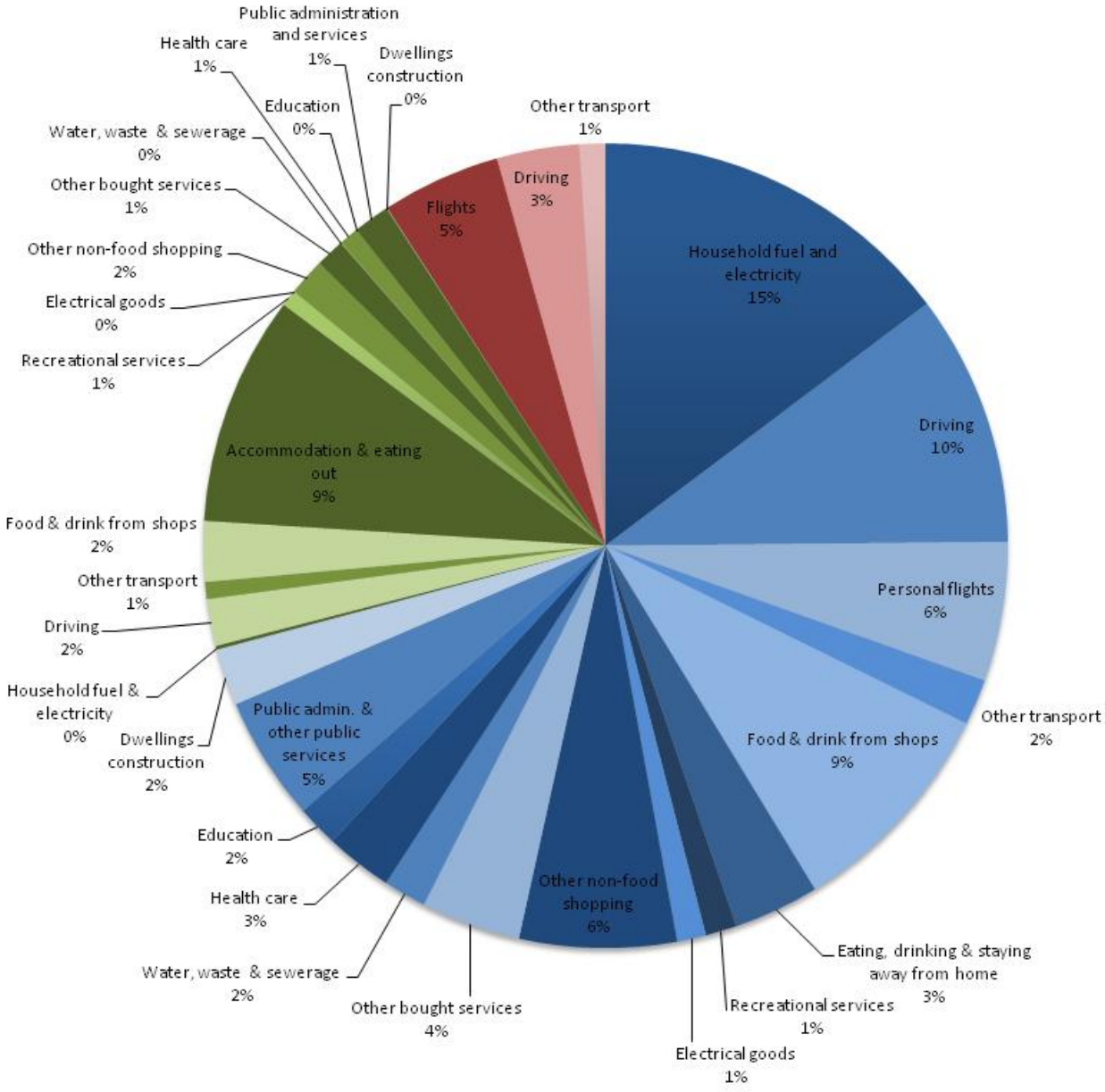

Figure 6: The total footprint of Cumbria's residents and visitors; 11 million tonnes CO_2e.
(Blue: residents; Green: visitors; Red: visitors there and away)

The figure below combines the emissions from resident and visitors within types of consumption. This further highlights the significance of driving, accommodation and food.

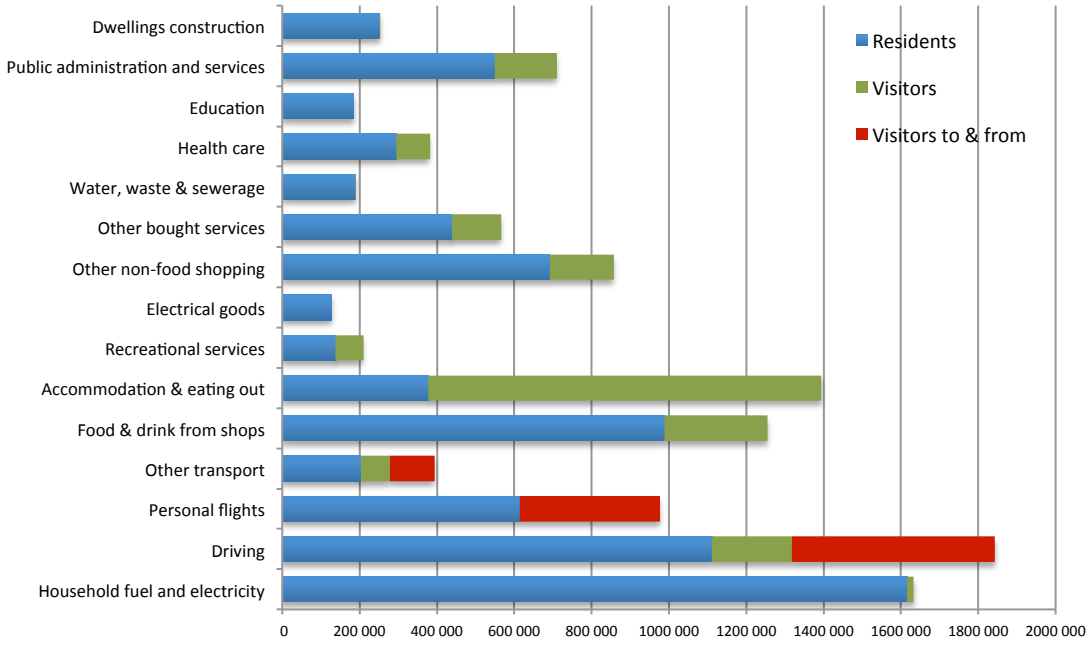

Figure 7: Cumulative totals of resident and visitor emissions by emissions source (tonnes CO_2e) (Blue: residents; Green: visitors; Red: visitors there and away)

	***Per capita* emissions (t CO_2e)**				**Totals**			
	UK average	Cumbria resident	Cumbria visitor (exc. T&A)	Cumbria visitor there & away	Cumbria resident	Cumbria visitor (exc. T&A)	Cumbria visitor T & A	All
Household fuel and electricity	3.20	3.27	0.12	-	1,615,818	16,834	-	1,632,652
Driving	2.33	2.25	1.43	2.50	1,111,525	206,879	361,995	1,680,398
Personal flights	1.24	1.24	-	3.62	614,869	-	524,719	1,139,589
Other transport	0.44	0.41	0.52	0.79	203,224	75,243	114,830	393,297
Food & drink from shops	2.03	2.00	1.84	-	987,656	266,654	-	1,254,311
Accommodation & eating out	0.83	0.76	7.01	-	377,850	1,016,134	-	1,393,984
Recreational services	0.30	0.28	0.50	-	137,771	72,556	-	210,327
Electrical goods	0.27	0.26	-	-	127,145	-	-	127,145
Other non-food shopping	1.48	1.40	1.14	-	692,224	164,846	-	857,070
Other bought services	0.93	0.89	0.89	-	438,228	128,416	-	566,645
Water, waste & sewerage	0.40	0.38	0.01	-	189,193	1,971	-	191,164
Health care	0.61	0.60	0.60	-	295,206	86,506	-	381,712
Education	0.41	0.37	-	-	184,147	-	-	184,147
Public administration & services	1.23	1.11	1.11	-	549,711	161,085	-	710,796
Dwellings construction	0.54	0.51	0.02	-	251,078	2,616	-	253,693
Total	16.25	15.73	15.18	6.91	7,775,647	2,199,739	1,001,544	10,976,930

Table 1: Comparison of *per capita* emissions and totals (tonnes CO_2e)

3.2 Breakdown of the footprint of residents

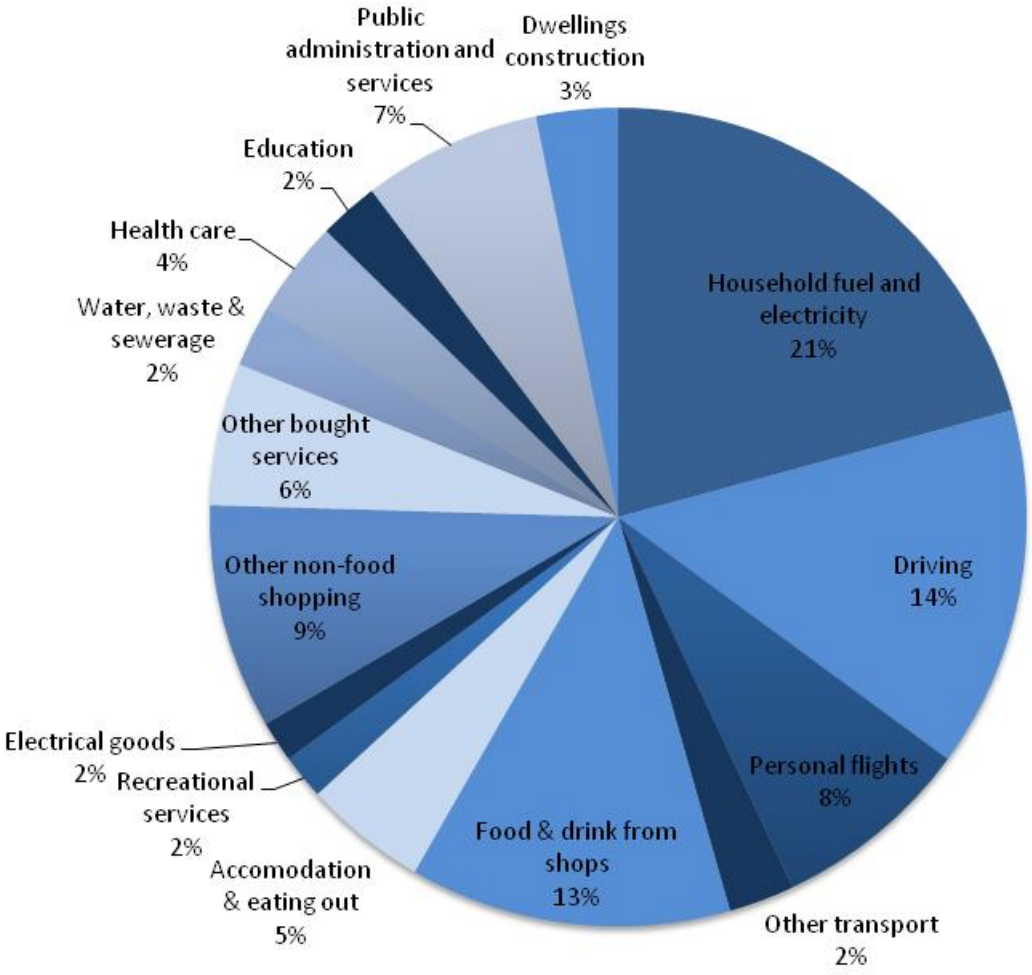

Figure 8: The total footprint of Cumbria residents; 7.8 million tonnes CO_2e

21% (1.6 million tonnes CO_2e) of the resident's footprint is attributed to household fuels and electricity, predominantly electricity and gas but with some contribution from coal, oil and other fuels. This is approximately 3.27 tonnes CO_2e *per capita* per annum, slightly higher than the UK average.

Driving contributes a further 14% (1.1 million tonnes CO_2e), 62% (688 thousand tonnes CO_2e) of which are the emissions embodied in fuel, the rest comes from the retail, manufacture and maintenance of vehicles. This equates to 2.25 tonnes CO_2e *per capita* per annum, slightly below the UK average of 2.33 tonnes CO_2e.

Flights taken by Cumbria residents contribute a further 8% to the overall footprint and travel habits are assumed UK typical. Other transport related emissions add a further 2%, so that household energy and transport between then make up almost half (46%) of the total carbon footprint.

The other half of the footprint is a mixture of embodied carbon in goods, food (13%) as well as all inedible items (9%) and a wide range of services (from hotel accommodation to financial services) and public services such as education (2%), health care (4%), defence and government (7%). The building, maintenance and improvement of homes accounts for about 3% of the total.

3.3 Detailed composition of the footprint of residents

There is some variation between residents of the different Districts, with Eden having the lowest *per capita* footprint at 14.6 tonnes CO_2e per year and Copeland, the highest, at 16.6 tonnes CO_2e per year. There are also differences between Districts in the profile of these emissions. For example while Allerdale's residents have higher than average consumption of household fuels and electricity their consumption of goods and services are amongst the lowest in the County.

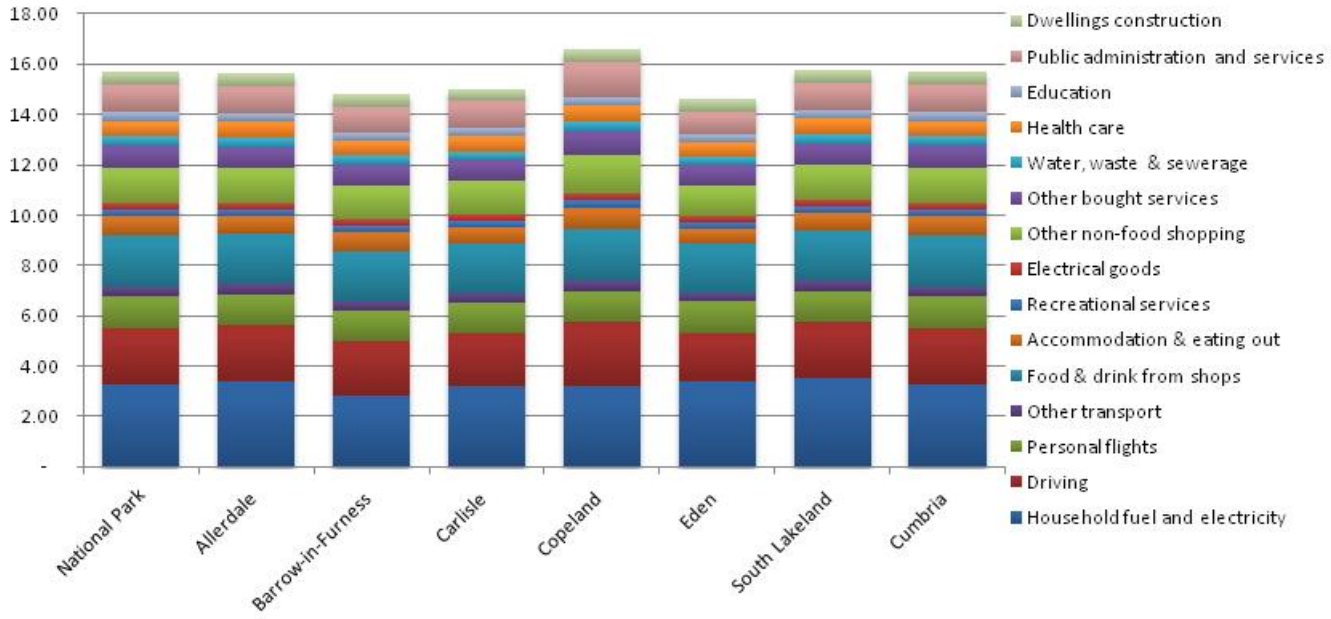

Figure 9: Breakdown of *per capita* emissions by District and source of emissions (tonnes CO_2e)

	LDNP	Allerdale	Barrow-in-Furness	Carlisle	Copeland	Eden	South Lakeland	Cumbria average	UK average
Household fuel and electricity	3.27	3.39	2.81	3.20	3.20	3.42	3.52	3.27	3.20
Driving	2.25	2.23	2.17	2.10	2.53	1.91	2.23	2.25	2.33
Personal flights	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24
Other transport	0.41	0.40	0.39	0.37	0.44	0.35	0.40	0.41	0.44
Food & drink from shops	2.00	1.99	1.98	1.96	2.05	1.93	1.99	2.00	2.03
Accommodation & eating out	0.76	0.73	0.71	0.67	0.85	0.62	0.73	0.76	0.83
Recreational services	0.28	0.27	0.26	0.24	0.31	0.23	0.27	0.28	0.30
Electrical goods	0.26	0.26	0.26	0.26	0.27	0.25	0.25	0.26	0.27
Other non-food shopping	1.40	1.36	1.34	1.30	1.49	1.24	1.36	1.40	1.48
Other bought services	0.89	0.87	0.85	0.83	0.94	0.80	0.87	0.89	0.93
Water, waste & sewerage	0.38	0.37	0.37	0.36	0.40	0.35	0.38	0.38	0.40
Health care	0.60	0.60	0.58	0.58	0.62	0.55	0.59	0.60	0.61
Education	0.37	0.33	0.32	0.32	0.37	0.34	0.36	0.37	0.41
Public administration & services	1.11	1.11	1.04	1.09	1.38	0.91	1.09	1.11	1.23
Dwellings construction	0.51	0.48	0.48	0.48	0.52	0.47	0.49	0.51	0.54
Total	15.73	15.62	14.80	15.02	16.61	14.60	15.77	15.73	16.25

Table 2: Breakdown of *per capita* emissions by District and source of emissions (tonnes CO_2e)

3.3.1 Household energy (21% of total footprint)

Household energy accounts for 21% of all emissions, of this 62% are from domestic fuel (mainly gas) and 38% from electricity.

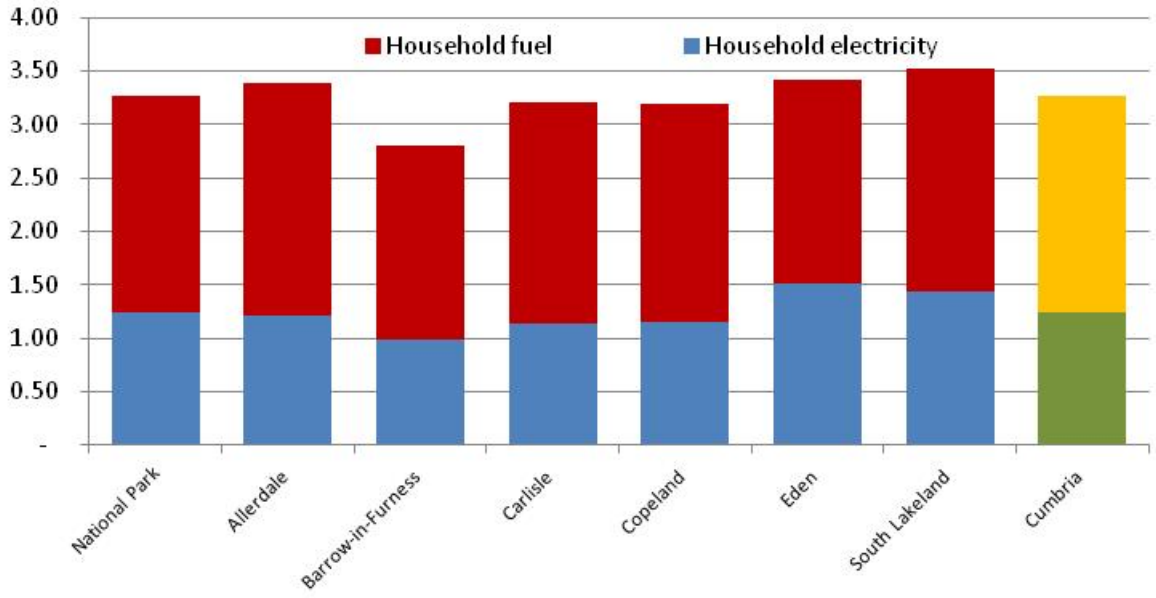

Figure 10: *Per capita* emissions from household energy by District (tonnes CO_2e).

Some District level variation in household fuel consumption is evident. Residents in South Lakeland have the highest rates of consumption of household energy at approximately 3.52 tonnes CO_2e *per capita*, 25% higher than Barrow-in-Furness, the District with the lowest consumption *per capita* at 2.81 tonnes CO_2e per annum.

This variation results from different levels of consumption combined with different composition of the fuel mix. For example residents in Barrow-in-Furness consume only 10% of more carbon intensive fuels such as coal and petrol compared to the County average while retaining an average consumption of gas. In another example Allerdale residents consume 7% more household fuel overall than the County average and 19% more than Barrow-in-Furness the District with the lowest *per capita* emissions.

Similar patterns are seen in electricity consumption with Eden's residents consuming 22% more electricity than the average for the County, compensated slightly by 6% less than average consumption of household fuels.

3.3.2 Driving (14% of total footprint)

The footprint of driving includes vehicle fuel (688 thousand tonnes CO_2e; 8.8% of the total) of which around three quarters of the emissions from the fuel come directly out of car exhaust pipes, with the other quarter arising from the fuel supply chains of extraction, transport and refining. In addition the emissions embodied in the retail, manufacture and maintenance of cars contribute a further 424 thousand tonnes CO_2e (5.4% of the resident footprint), taking the total footprint of driving to 14% of the total resident footprint.

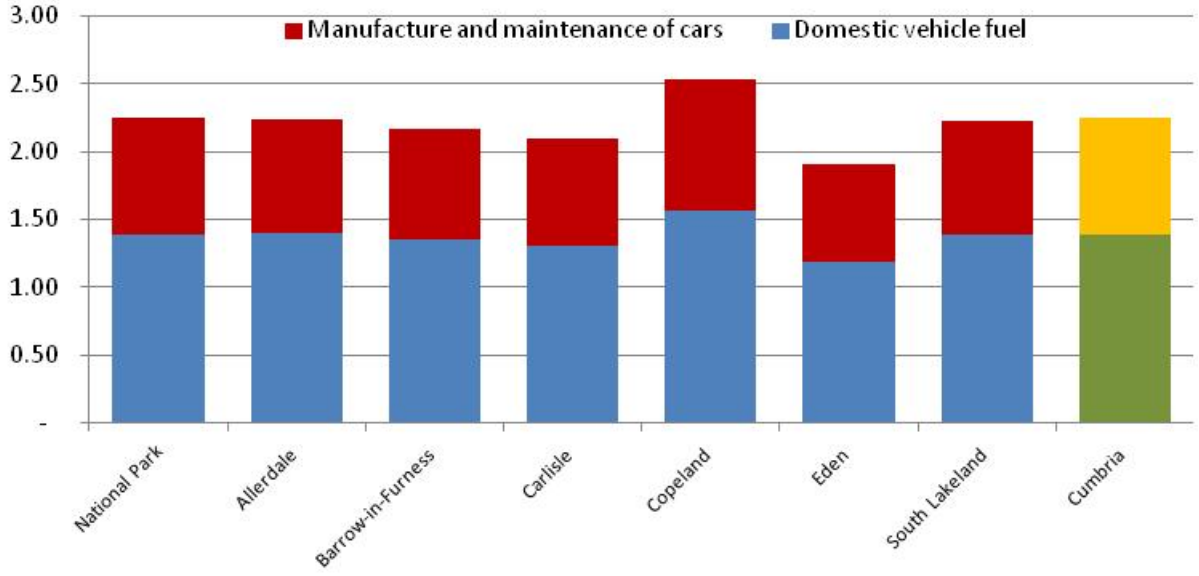

Figure 11: The footprint of driving for residents in each District (tonnes CO_2e).

As with household energy the *per capita* emissions from driving vary across Cumbria's Districts, ranging from 2.53 tonnes CO_2e *per capita* in Copeland to 1.91 tonnes CO_2e *per capita* in Eden, with an average of 2.33 for the County. This results from differences in reported family expenditure on cars and vehicle fuel across the County[3].

3.3.3 Flights (8% of total footprint)

Bespoke data in resident flight habits exists[4] however was beyond the budget for this report, without it there was no basis to assume than Cumbria residents flight habits differ substantially from UK average, therefore no adjustment was made.

Thus the *per capita* emissions from flying were approximately 1.24 tonnes CO_2e per annum, totalling around 615 thousand tonnes CO_2e for the County, 8% of the resident footprint.

3.3.4 Food and drink from retail (13%)

This section does not include food and drink purchased from restaurants, cafes, pubs, hotels or that consumed by industry (for example in business lunches), or through the delivery of public services, such as school and hospital meals. Nor does it include emissions resulting from the cooking or wasting of food[5]. If all these components are added on, food accounts of around 20% of the total footprint. Some analyses suggest that if emissions changes in land–use resulting from food demand are taken into account, food should be considered to be around 30% of the UK's GHG footprint[6].

The two most critical factors in determining the footprint of food are diet and waste. As a broad generalisation, the high carbon diets are those with high meat and dairy contents, especially where there is high red meat content and most of all where the red meat is from ruminants (cows and sheep).

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[3] Based on data from Defra's family spending survey 2010 (see section 0 *Vehicles and vehicle fuel for details*).

[4] The Civil Aviation Authority holds data on this based on a Passenger survey conducted across UK airports.

[5] The emissions resulting from cooking are represented in 'household fuel' and 'household electricity'. Those from waste appear in the 'water, waste and sewerage' category.

[6] Audsley, *et al.* (2010)

For many there are opportunities to save money and improve health whilst shifting to a lower carbon diet.

The average UK person is thought to waste around 25% of the edible food that they purchase[7] and reducing this presents a clear opportunity to improve household prosperity whilst cutting the carbon. Other factors in the footprint of food are the purchase of out-of-season produce (resulting in hot-housing or airfreight) and excessive packaging (although some packaging is beneficial in helping to reduce waste). Interestingly, food miles by boat are not usually an important factor in the footprint of foods.

Our analysis of differences between regions was based on socio-economic analysis and showed only around a 6% difference between the highest and lowest regions. Two factors account for this. Firstly, whilst there is evidence that wealthy households have somewhat more carbon intensive diets; the difference is less than proportional to the wealth difference. Secondly, each District taken as a whole contains a wide and relatively similar socio demographic mix. An analysis of carbon by income group shows greater difference than analysis by District.

3.3.5 Eating, drinking, staying and recreation away from home (4.9% of total)

This includes hotels, pubs, restaurants, cafes and leisure facilities. Around half the emissions in this category stem from food.

The most important considerations for carbon efficiency are low carbon food (menus, portion control and minimising kitchen waste), energy efficiency and low carbon procurement.

3.3.6 Non food shopping (8.9% of total)

This category includes a wide variety of goods. Some key components are worth noting:

- electrical goods,
- clothing and footwear,
- furniture, carpets and other household textiles,
- books, paper and published materials,
- soaps and toiletries and pharmaceuticals,
- jewellery.

A lower carbon Cumbria culture and economy might include habits and business infrastructure to support second hand markets and the repair and maintenance of goods of every kind. In addressing this section of the footprint there are opportunities for households to be better off and for relevant businesses to thrive as well as reducing manufacturing emissions and waste.

3.3.7 Health care (3.8%)

Health improvement through, for example, increased cycling, walking and better diets also stand to bring about reductions in multiple parts of the footprint, as well as delivering wellbeing benefits.

3.3.8 Education (2.4%)

In addressing this section there are possibilities to save money through energy and resource efficiency, but perhaps more importantly, to educate for low carbon consumption.

[7] WRAP (2008)

3.3.9 Household construction (3.2%)

Around 80% of this is new construction, the rest is maintenance and home improvement. Reduction of this part of the footprint is not the priority, since the quality with which it is done can have a disproportionate beneficial effect on household energy use.

Planners have an important role in ensuring sustainable new builds in terms of energy efficiency, as well as location and layouts that enable low carbon lives.

3.3.10 Public administration, defence and other public services (7.1%)

Within this part of the footprint are allocations for nationally delivered services such as central government and the armed forces, both of which are outside the control of Cumbria residents or local government.

However, the Council and other local providers have an important role to play in managing their own footprints. Much of this can be aligned with resource efficiency and cost savings, especially through low carbon procurement and energy efficiency.

3.3.11 Water, waste and sewage (2.4%)

The majority of the footprint here comes from sewage and waste treatment rather than water supply and the carbon footprint reductions from reduction in household water usage are relatively limited, even though these actions are important in their own right.

3.3.12 Other bought services (5.6%)

The largest components of this category are:

- Banking, finance and insurance (1.8%).
- Letting of dwellings (1.8%)
- Telecommunications' (0.7%)

These may be difficult parts of the consumption footprint for either residents or local government to take action to reduce.

3.4 Breakdown of the footprint of visitors

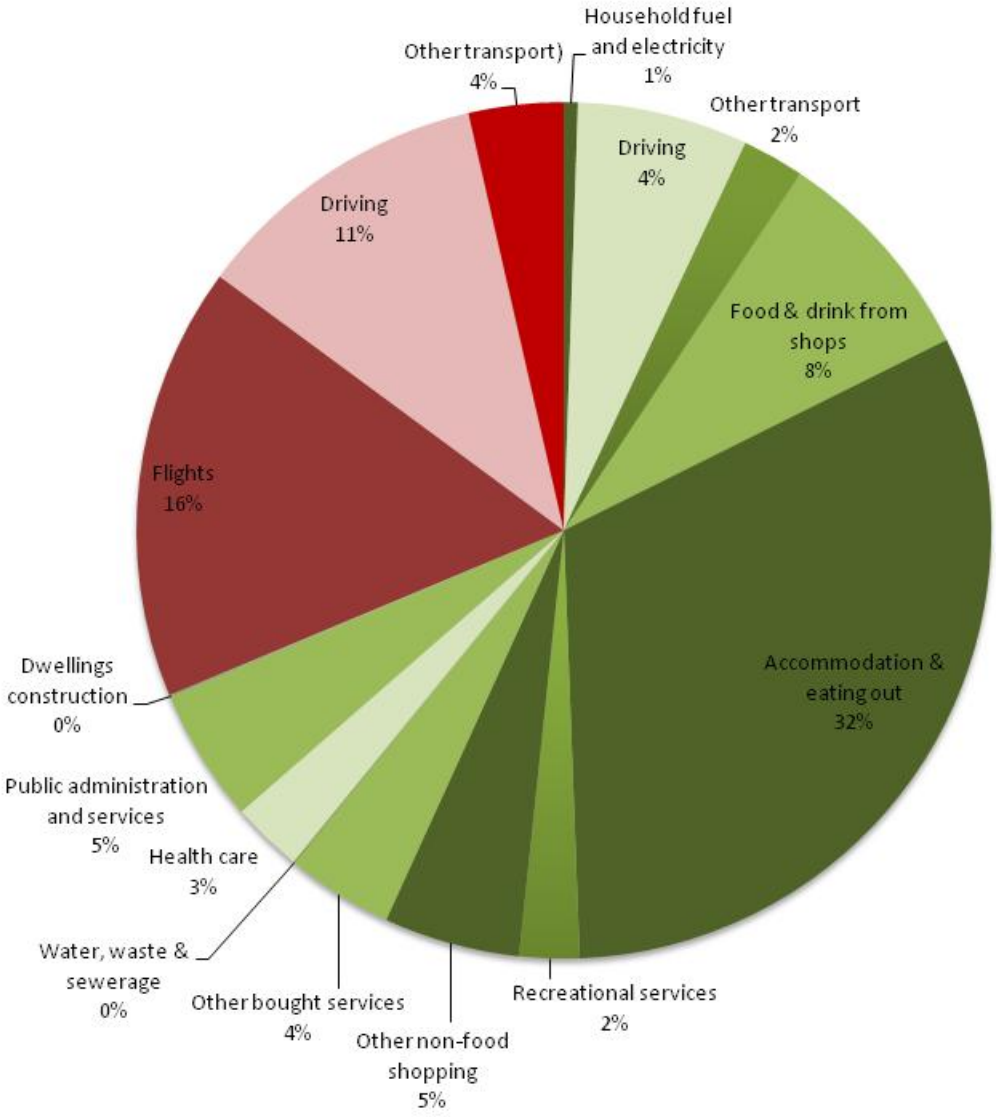

Figure 12: The total footprint of Cumbria's visitors; 3.2 million tonnes CO_2e (Green: visitors during stay; Red: visitors there and away)

3.4.1 Accommodation and eating out

The largest source of emissions from Cumbria's visitors are those resulting from accommodation and eating out resulting in approximately 1 million tonnes CO_2e per annum (32%). This is unsurprising and combined with a contribution from food and drink from retail (8%) the emissions from accommodation and food rival that of Cumbria residents.

In total the emissions from this area for residents and visitors combined make up 24% of the overall footprint highlighting an important area for management.

3.4.2 Visitor travel

Visitor travel makes up another large contributor to the footprint, split into travel to and from Cumbria (shown in red; 31% of the visitor footprint), and travel within Cumbria (in green; 6%).

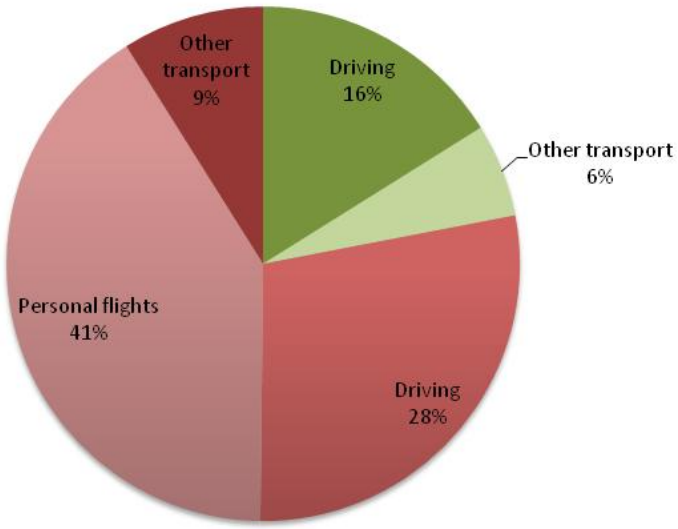

Figure 13: Breakdown of the emissions from visitor transport (1.3 million tonnes CO_2e) (Green: visitor travel during stay; Red: visitors travel there and away)

Despite overseas visitors only being a small proportion of visitors to Cumbria the emissions resulting from their flights to the Country are significant[8] 41% of the footprint of visitor travel and 5% of the total footprint of residents and visitors. With a similar contribution from residents (615 thousand tonnes CO_2e) flying contributes 15% of the overall footprint and is another important area for management.

Driving contributes 34% of the footprint of visitor travel and when combined with the emissions from resident driving 10% of the total footprint of residents and visitors. The contribution from other transport is small; 15% of visitor travel; 4% of the overall footprint when combined with resident consumption. This is likely to be a reflection of insufficient service provision and could provide a fruitful area for management.

3.4.3 Other

Household fuel and electricity, water, waste and sewerage and dwellings construction are only very small proportions of the footprint as these are largely covered in the footprint of the tourism industry.

Purchases of other non-food shopping, services and electrical goods are relatively insignificant areas which are likely to be difficult to manage.

Public services are not actively consumed by visitors, or residents, and include both local service provision and a proportional allocation of national service provision. Management of procurement and resource efficiency in the County Council and other local services is likely to provide difficult to quantify but valuable savings in this area.

3.5 Detailed composition of the footprint of visitors

As visitor days are spread unevenly across the County, so too is the footprint of the goods and services they consume, meaning that the impacts of visitors are likely to be of greater importance to some Districts than others.

[8] Emissions are allocated to Cumbria in proportion to the length of stay compared to length of stay of overseas visitors to the UK on average.

South Lakeland hosts approximately 40% of all visitor days in Cumbria, greater than the total of Allerdale (18%) and Carlisle (16%) combined, the Districts with the next highest visitor days[9]. Consequently the carbon footprint shows many of the same trends.

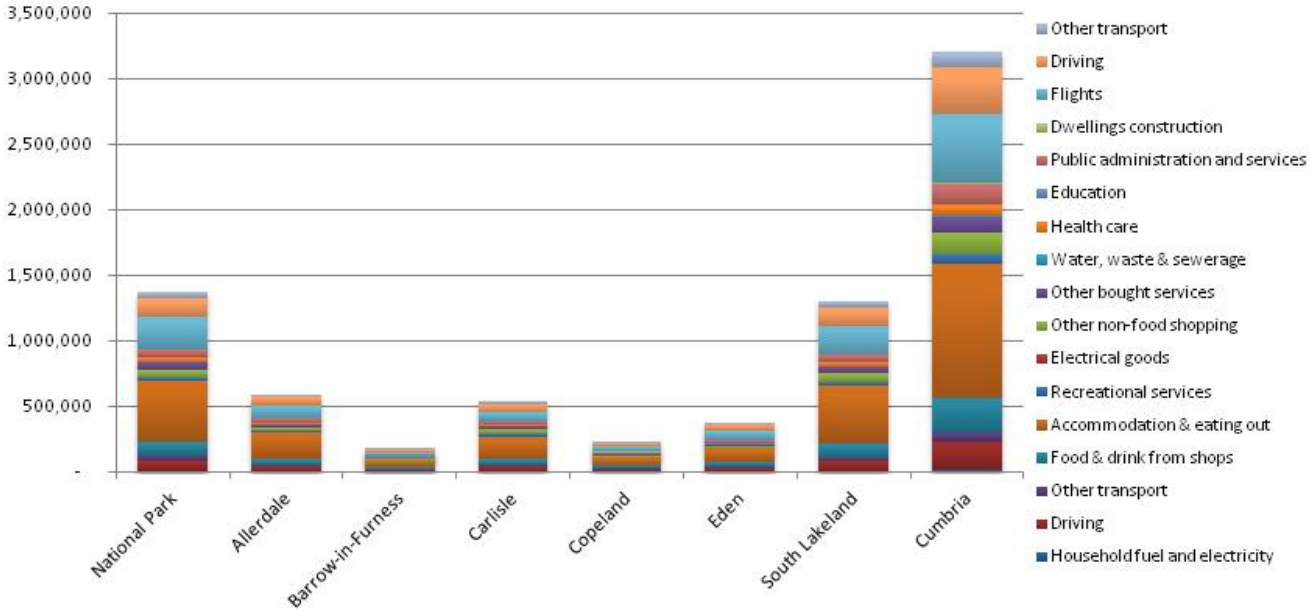

Figure 14: Total visitor emissions broken down by District and by source of emissions (tonnes CO_2e)

	LDNP	Allerdale	Barrow-in-Furness	Carlisle	Copeland	Eden	South Lakeland	Cumbria
Household fuel and electricity	1,417	3,185	2,509	3,436	2,189	1,742	3,681	16,834
Driving	87,162	37,208	12,157	33,890	16,111	25,610	81,897	206,879
Personal flights	-	-	-	-	-	-	-	-
Other transport	30,482	13,152	4,707	13,284	5,812	8,739	29,551	75,243
Food & drink from shops	109,864	48,112	15,791	44,198	21,153	34,175	103,235	266,654
Accommodation & eating out	461,366	197,630	47,512	172,478	59,068	106,383	433,062	1,016,134
Recreational services	27,729	10,328	7,899	18,692	2,199	4,626	28,813	72,556
Electrical goods	-	-	-	-	-	-	-	-
Other non-food shopping	56,859	25,918	5,432	38,155	10,849	14,525	69,967	164,846
Other bought services	54,690	22,734	7,121	19,379	10,607	14,550	49,975	128,416
Water, waste & sewerage	166	352	329	388	277	176	393	1,971
Health care	36,841	15,750	4,863	13,515	7,010	9,980	33,661	86,506
Education	-	-	-	-	-	-	-	-
Public administration & services	68,603	29,108	8,720	25,266	15,613	16,684	62,908	161,085
Dwellings construction	220	454	431	519	354	239	512	2,616
Flights	246,927	102,443	24,807	65,699	41,888	77,145	212,737	524,719
Personal transport (car & motorbike)	141,357	61,625	23,879	68,063	27,751	39,549	141,149	361,995
Public transport (bus, coach, train)	44,209	19,351	7,722	22,086	8,778	12,248	44,653	114,830
Total	1,367,893	587,350	173,881	539,049	229,658	366,372	1,296,194	3,201,283

Table 3: Total visitor emissions broken down by District and by source of emissions (tonnes CO_2e)

[9] Cumbria Tourism (2010)

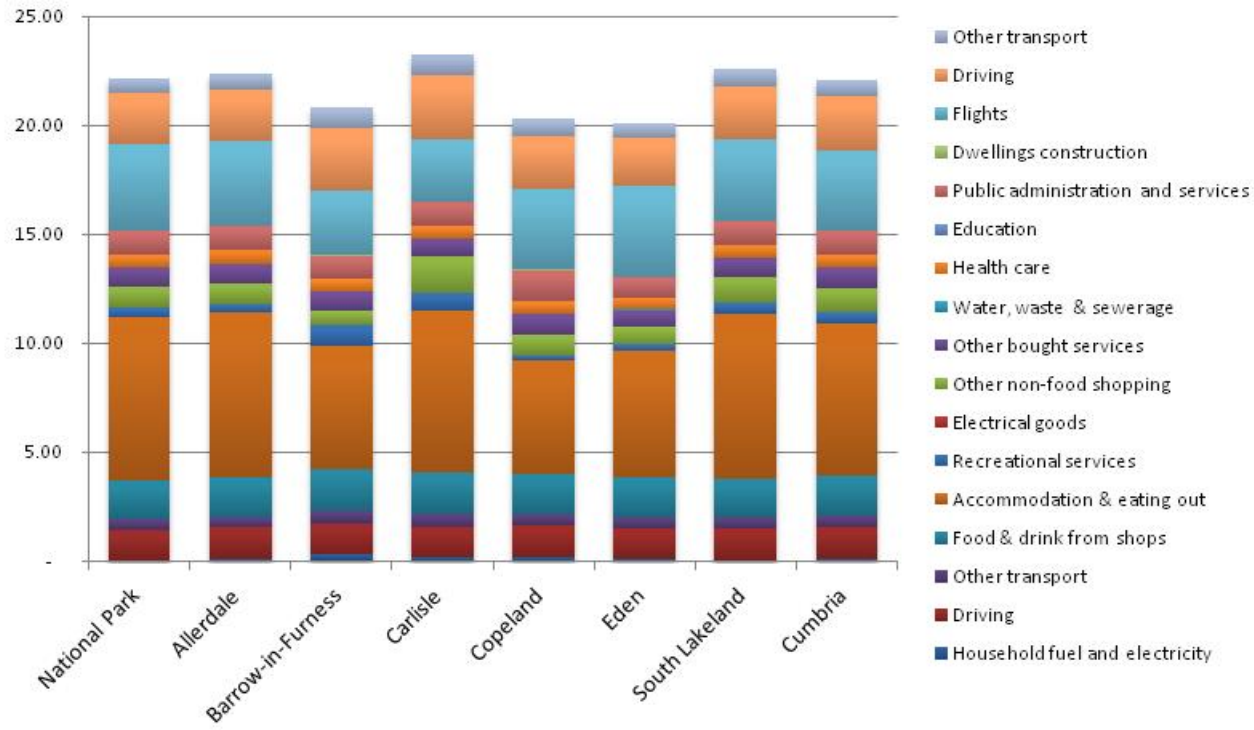

Figure 15: *Per capita* visitor emissions broken down by District and emissions source (tonnes CO_2e)

	LDNP	Allerdale	Barrow-in-Furness	Carlisle	Copeland	Eden	South Lakeland	Cumbria
Household fuel and electricity	0.02	0.12	0.30	0.15	0.19	0.10	0.06	0.12
Driving	1.41	1.42	1.45	1.46	1.42	1.40	1.42	1.43
Personal flights	-	-	-	-	-	-	-	-
Other transport	0.49	0.50	0.56	0.57	0.51	0.48	0.51	0.52
Food & drink from shops	1.78	1.83	1.89	1.90	1.87	1.87	1.80	1.84
Accommodation & eating out	7.48	7.53	5.68	7.43	5.22	5.83	7.53	7.01
Recreational services	0.45	0.39	0.94	0.81	0.19	0.25	0.50	0.50
Electrical goods	-	-	-	-	-	-	-	-
Other non-food shopping	0.92	0.99	0.65	1.64	0.96	0.80	1.22	1.14
Other bought services	0.89	0.87	0.85	0.83	0.94	0.80	0.87	0.89
Water, waste & sewerage	0.00	0.01	0.04	0.02	0.02	0.01	0.01	0.01
Health care	0.60	0.60	0.58	0.58	0.62	0.55	0.59	0.60
Education	-	-	-	-	-	-	-	-
Public administration & services	1.11	1.11	1.04	1.09	1.38	0.91	1.09	1.11
Dwellings construction	0.00	0.02	0.05	0.02	0.03	0.01	0.01	0.02
Flights	4.00	3.90	2.97	2.83	3.70	4.23	3.70	3.62
Personal transport (car & motorbike)	2.29	2.35	2.86	2.93	2.45	2.17	2.46	2.50
Public transport (bus, coach, train)	0.72	0.74	0.92	0.95	0.78	0.67	0.78	0.79
Total	22.17	22.36	20.80	23.22	20.31	20.08	22.55	22.10

Table 4: *Per capita* visitor emissions broken down by District and emissions source (tonnes CO_2e)

3.5.1 Accommodation and all food and drink

There is little variation in this category. The Districts with visitors staying with friends and family have the lowest emissions. Copeland, South Lakeland and Eden and Carlisle have *per capita* emissions above average (all around 9.3 tonnes CO_2e *per capita*).

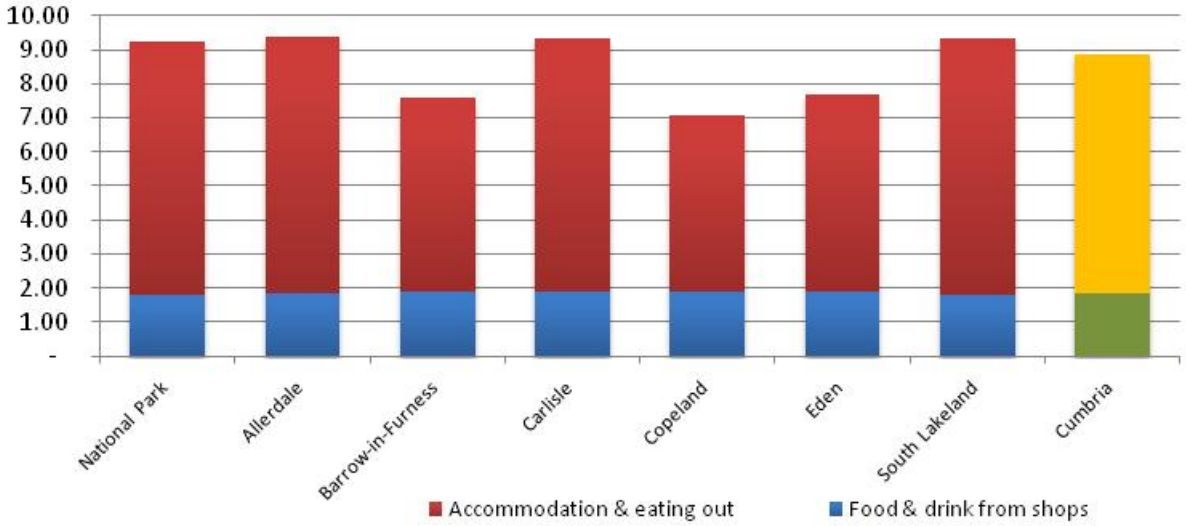

Figure 16: *Per capita* emissions from visitor accommodation, food and drink (tonnes CO_2e)

3.5.2 Visitor travel

There is little variation on *per capita* emissions but the areas with the greatest number of overseas visitors stand out as those with higher emissions. The graph showing District variation in total emissions from visitor travel shows some more pronounced differences with the National Park and the Districts it encompasses having much higher emissions. This is mainly due to the difference in visitor numbers but also due to a greater proportion of overseas visitors and UK visitors travelling greater distances for their stay.

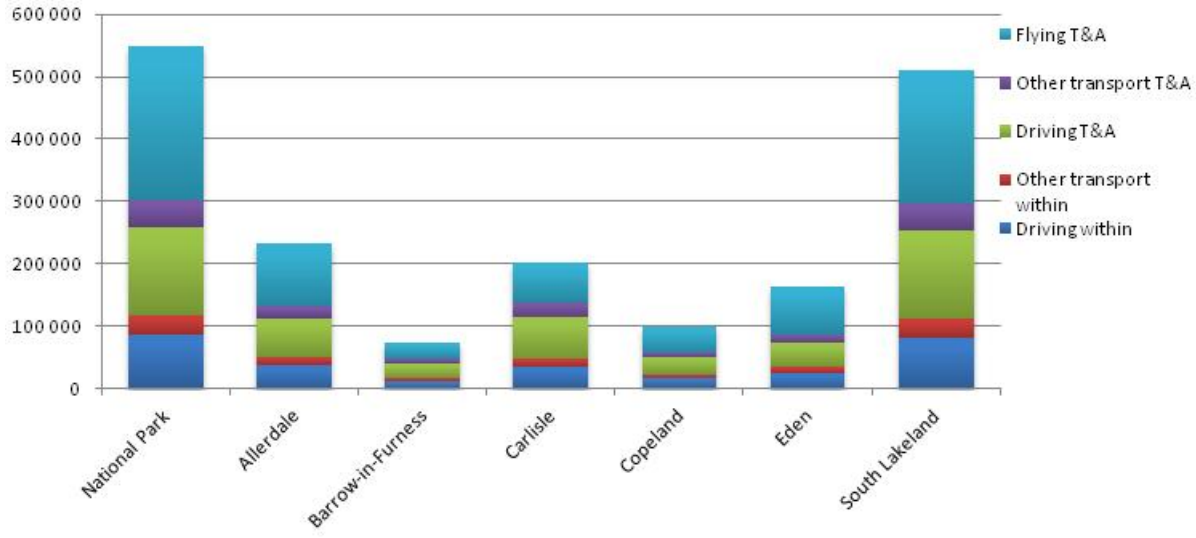

Figure 17: Total emissions from visitor travel by District (tonnes CO_2e)

4 The carbon footprint of industry

4.1 Overview

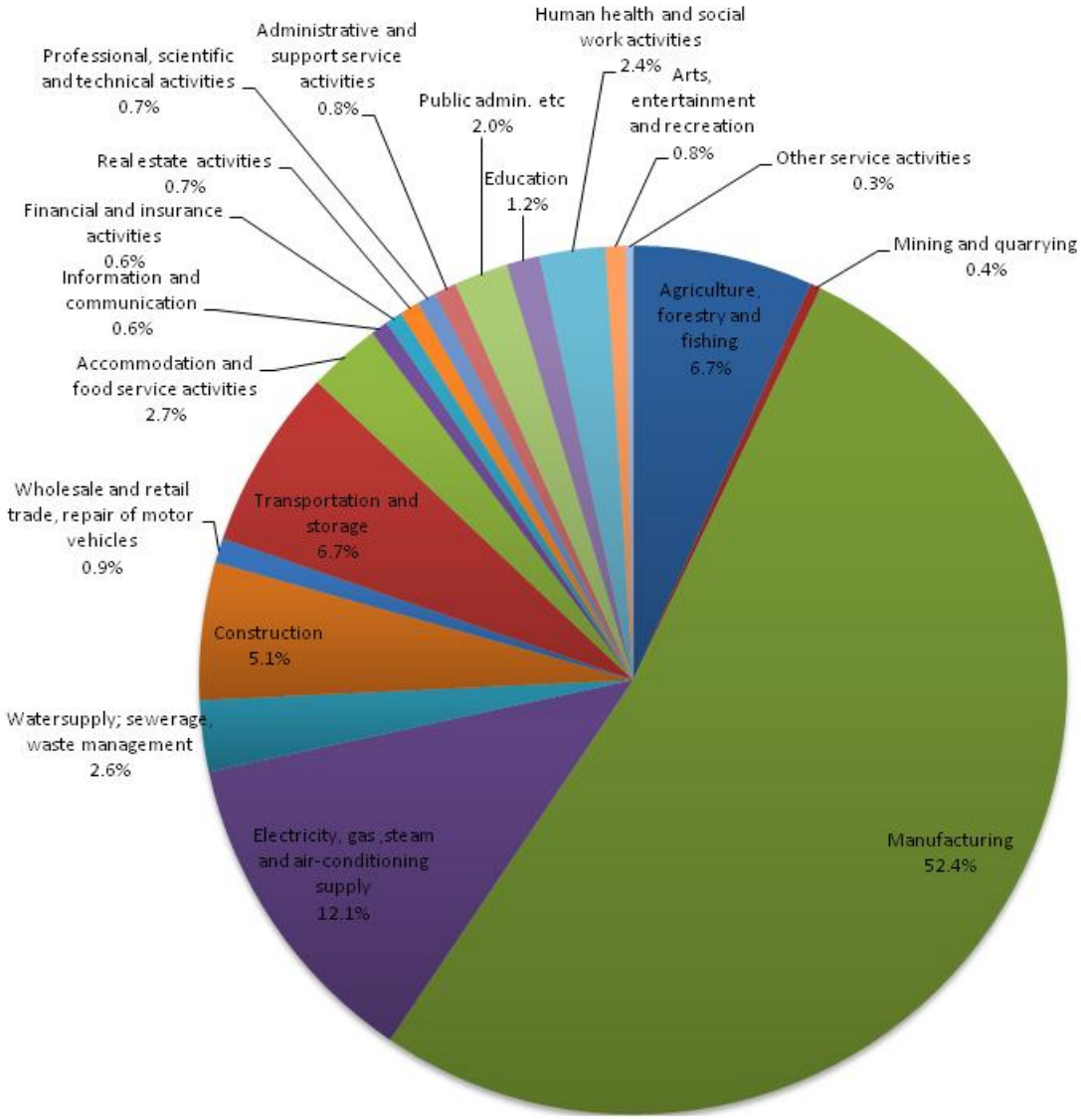

Figure 18: Breakdown of the carbon footprint of Cumbria's industry by sector; 15.7 million tonnes CO_2e

Our estimate for the sum of the carbon footprints of all Cumbria industries is 15.7 million tonnes CO_2e. This figure includes direct emissions, emissions from electricity consumption and indirect emissions in the supply chains. It is important to note that these supply chains overlap somewhat, so the total figure includes some double counting, for example where the direct emissions for one industry are also in the supply chains of another. However, the total figure gives an indication of the scope for carbon management since where double counting exists; there are also correspondingly multiple opportunities to manage the carbon.

4.2 Detailed composition of Cumbria industries' footprint

4.2.1 Manufacturing (52.4%)

Production is a broad category covering different types of products with different carbon characteristics. For some goods (such as cement) the majority of emissions are released directly in the production process, whilst for others (such as processed foods) the overwhelming majority of emissions lie in the supply chains of purchased materials or ingredients.

4.2.2 Electricity, gas, steam and air conditioning supply (12.1%)

Energy consumption makes up the majority of emissions (61%) in these industries.

4.2.3 Transport and storage (6.7%)

In transport based industries, energy use dominates the footprint. In the case of public transport, whilst energy efficiency is important, even more important is the improvement of alternatives to the car.

4.2.4 Agriculture, forestry and fishing (6.7%)

Within agriculture, forestry and fishing the majority of emissions occur on farms. In the case of sheep and cattle farming methane is the primary global warming gas, with emissions from rumination, as well as from manure and slurry. Nitrous oxide is also an important contributor, with emissions resulting mainly from the application of nitrogen fertilizer. Within horticulture, the primary source of emissions is as a result of hot-housing unseasonal produce. Supply chains are also significant for the agricultural sector, especially in the production of feed and fertilizer.

The science of agricultural emissions per unit yield is complex and as yet poorly understood. To add to the complexity, the assessment of environmental agricultural practice must also take account of other criteria such as biodiversity and impacts on water quality. Despite all this complexity it will be possible to discern some simple and important guidelines, which can be used to improve both the sustainability and the competitiveness of the local industry. These might include, for example, energy efficient horticulture, greater emphasis on seasonal produce and well timed, optimised application of fertilizer.

4.2.5 Public administration, education and health (5.6% combined)

Within public administration, education and health, the majority of emissions take place in the supply chains. The implication for carbon management is that priority should be placed on low carbon procurement and resource efficiency. In a time of austerity, it is also worth noting that these measures also stand to yield significant cost savings.

Schools, colleges and universities have an important role to play in developing literacy in consumption based carbon calculation. Actions taken in this sector are even more important for their educational value as their direct impact, carbon management should emphasise the importance of indirect emissions. There is a strong case for visible initiative to tackle such things as food waste, diet and unnecessary use of resources.

4.2.6 Construction (5.1%)

The vast majority of the footprint of this industry lies in the supply chains of its materials. Even more important than this, however, and not included in this study, are in-use emissions from buildings after construction and the contribution of this industry to sustainable infrastructure in Cumbria. Well targeted energy efficiency retrofits are highly carbon beneficial.

4.2.7 Accommodation and food services (2.7%)

Within hotels, pubs, restaurants and catering services, food and drink accounts for around half of the footprint and energy use typically less than 20%. Carbon management in these businesses should reflect this, especially since the opportunities for cost savings through waste reduction are often far greater than those that are possible through energy savings.

4.2.8 Other (<10%)

The remainder of the footprint emanates from a complex mixture of industries, predominately service activities. With the exception of water supply, sewerage and waste management (2.6%) the majority of the footprint for these industries is embodied in their supply chains and businesses seeking to manage their carbon should be encouraged to focus on their procurement and resource efficiency, raising their game from focussing purely on energy efficiency.

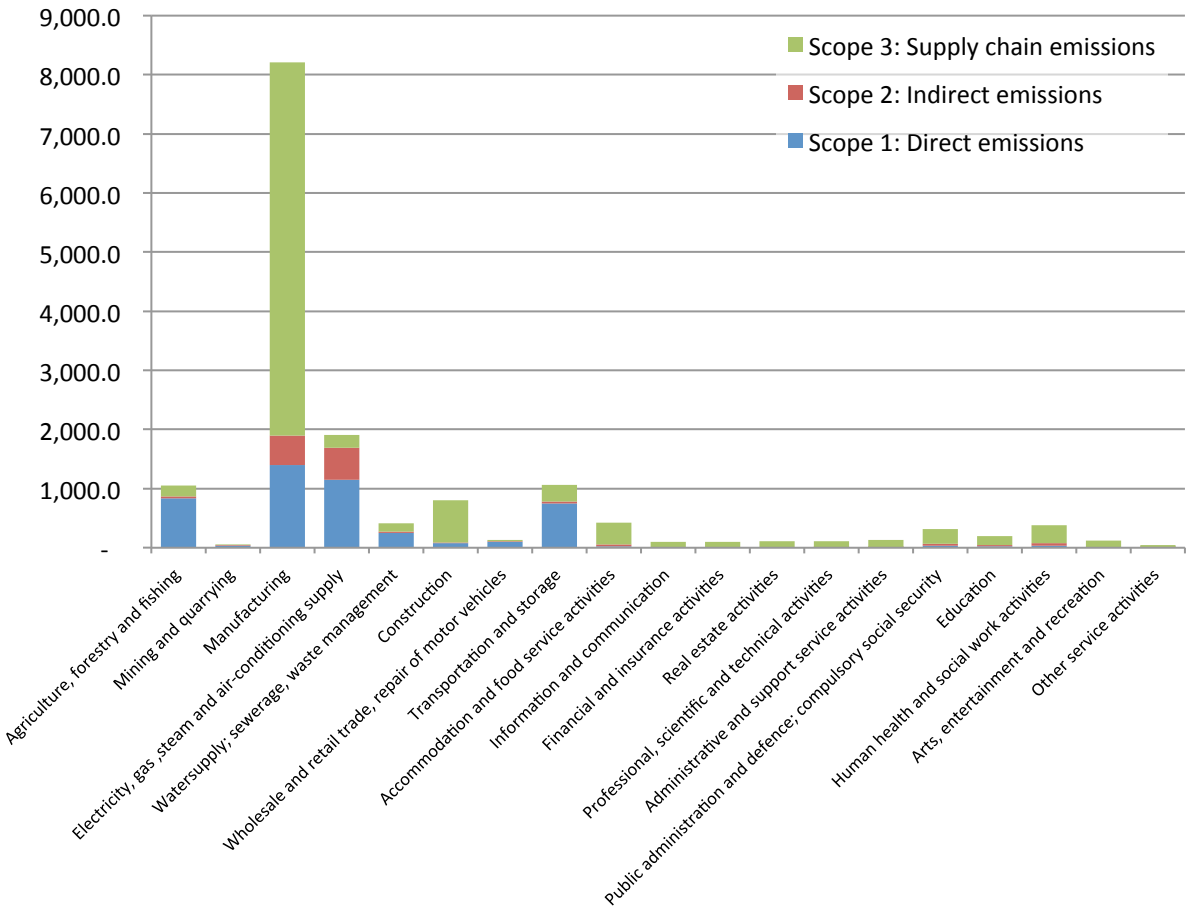

Figure 19: Carbon footprint of Cumbria industry showing the relative contribution of scopes 1, 2 and 3 (thousand tonnes CO_2e).

5 Recommendations and the process from here

5.1 Process recommendation

Information about emissions should be combined with other criteria, such as economic and social benefits. The criteria for prioritising projects should include of the following:

- Likely carbon savings
- Economic costs and benefits of the action, in the short and longer term (some actions may require investment but will result in savings over the medium to long term)
- Social costs and benefits, with a particular focus on distributional effects
- Organisational strategy and priorities of each organisation within the Cumbria Chief Executives Group, as well as priorities of the Group as a whole
- The fit with national and EU policy and objectives, such as the Government's new Green Deal which will fund energy efficiency investment; the strategy for renewable energy, and so on
- The availability of funding or investment, from public, commercial or charitable sources

The Cumbria Chief Executives Group, and each individual organisation within the group, will need to develop a set of locally-specific criteria, based on these general recommendations.

5.2 Key Areas

Based on these criteria, our initial recommendations for priority areas are as follows:

Building energy-use: This area is associated with significant emissions as well as costs for businesses and households. It fits with the Government's Green Deal proposals.

Travel: Finding ways to reduce the need to travel, and to improve efficiency of travel, has multiple benefits. There is potential to save residents money and time, and to improve the quality of the visitor experience, whilst diverting visitor spend into the local Economy. The GoLakes Travel project in the Central Lake District is an example of action in this area.

Repair, recycle and resale: Given the considerable significance of non-food shopping, any increase in repair, recycling and resale of consumer goods will bring about carbon savings. Focussing on developing these industries has potential to boost the local economy whilst reducing costs for households and businesses. Other local areas, including West Sussex, have been pioneering this approach.

Food: Focussing in particular on reducing waste and shifting towards lower carbon diets has potential to simultaneously improve health, wealth and wellbeing for residents and visitors. Local food also benefits the local economy.

Tourism: There is scope to enhance visitor experience and the economic benefits through encouraging tourism providers to improve their environmental performance. More efficient buildings, sourcing of local, seasonal food and drink, and promoting non-car transport are all important. If domestic tourism and longer stays are encouraged, there are clear economic benefits, and carbon is reduced too, as travel becomes a smaller component of both carbon and financial cost of the trip.

5.3 Where might savings come from

There is a range of ways to achieve these savings, the highest potential comes from the biggest sources of emissions.

5.3.1 Driving

The key options to reduce the footprint of driving are to reduce the number of miles driven, shift to more efficient cars and, perhaps, improve the style of driving.

If visitors can be persuaded to travel less and divert their expenditure into services on offer within Cumbria, the change is also likely to be accompanied by a marked increase in cash into the visitor economy. The footprint of travel to and from Cumbria can be reduced by increasing the average length of stay, if visitor days are unchanged. If visitor days were to rise as a result, the footprint per day would still be reduced by this action.

Lift shares to work provide a way reducing resident car miles as well as saving money for residents. A culture of using smaller cars where possible would also be helpful. Any changes leading to increases in the lifetime mileage of cars could also help.

5.3.2 Flights

Increasing the length of stay of overseas visitors is one way of reducing the footprint per visitor day. Another approach would be to alter the visitor mix, with a higher proportion coming from closer by. Expanding the capacity of regional airports will result in a significant rise in Cumbria's emissions.

5.3.3 Public transport

Interestingly, visitor car occupancy rates are thought to average 3.3 people per car. Once this is taken into account, although they may lead to improvements in the visitor experience, the carbon efficiency savings from using public transport compared to a fairly economical car are marginal. The same is not true of resident travel which would be improved by better bus and train infrastructure.

5.3.4 Accommodation, food and drink

The emphasis of carbon management activities in the hotel, pub and catering industry in Cumbria should reflect where the emissions come from within that industry. Food and drink makes up around 60%, and key mitigation activities might include waste reduction (pre- and post- plate) and menu choice, emphasising seasonality, locality (especially for heavy products such as beer and milk), ensuring lower meat options are high quality and avoiding air-freight and hot-housing. Energy efficiency measures are important, and other actions to consider are ensuring that visitors have a sense of responsibility for energy management and consumption, and cutting out unnecessary laundry.

All of these measures have potential to improve both bottom line and reputation. Some tourism businesses in Cumbria are already strongly engaged with this agenda. The activities of the Cumbria Green Business Forum demonstrates fertile ground for creating a core of lower carbon tourism businesses, together building and benefiting from Cumbria's potential reputation as a destination for sustainable tourism.

The above messages for carbon management in the catering industry also apply to home catering, other tourist attractions and leisure activities.

5.3.5 Household energy

In terms of priority, simple home energy efficiency measures such as insulation, draft exclusion, efficient boilers and low energy lighting are the most cost effective. Savings from micro-renewables or even double glazing are more expensive and should not be prioritised at the expense of more basic measures.

5.3.6 Non-food shopping

Amongst residents this might be tackled through re-use schemes (such as Freegle and second-hand shops) and promotion of infrastructure for repairing goods. Interestingly, these add to prosperity in ways which are not reflected in standard economic measures.

5.3.7 Public service organisations

Stakeholder organisations can take simple steps to ensure that they understand, at least in broad terms, the indirect emissions in their procurement supply chains as well as their direct emissions. Reducing these may well also result in improved resource efficiency and savings.

5.4 Illustrative actions

The following table indicates a number of ways, not all realistic, in which savings might be made. The savings are rough estimates and the table is an illustration rather than a complete list.

Table 5: An illustration of potential carbon savings

Management action	Approximate saving on the total	
	%	t CO_2e
Cut home energy consumption by 10%	1.5%	162,000
Cut domestic food waste to 20% (from 25%)	0.1%	15,000
Increase length of stay of visitors by 10%. (without changing visitor days)	0.9%	100,000
10% carbon efficiency improvement in education, health and other public services	1.2%	128,000
Reduce travel by visitors by 10%	0.3%	28,000
Ban cars within the National Park.	1.6%	181,000
Improve hotel, restaurant, café and pub carbon efficiency by 10%	1.3%	140,000
Ensure all beer is sourced locally	0.3%	35,000
Reduce resident purchase of non food-or-car goods by 10% through promotion of Re-use and repair services.	1.3%	138,000
Total (including some double counting)	8.4%	925,000

5.5 Taking this work forward

The options outlined above provide a starting point for Cumbrian organisations to develop a prioritised carbon saving action plan. Each organisation will need to examine the options, according to criteria which reflect their own aims and priorities.

Consideration should also be given to developing County-wide actions in a number of areas, in order to benefit from economies of scale. For example, there could be a Cumbria-wide programme on household energy efficiency, and Cumbria-wide policies to reduce vehicle usage by residents.

Once priorities are decided, organisations will need to develop a clear plan of actions, and implement those actions within an agreed timeframe. It is important to monitor the outcomes of such actions, both in terms of carbon saved, and other benefits, such as cost savings and social benefits.

The following sources of information and advice are available to Cumbrian organisations in developing this process:

The Local Government Association's Climate Local initiative, which includes a Commitment for Local Authorities to sign, and resources for officers, including a Knowledge Hub (www.local.gov.uk)

- CLASP, a support programme for NorthWest local authorities and public sector organisations, which helps the public sector reduce carbon emissions and adapt to climate change, through training, information provision and small grants (www.claspinfo.org)
- The work of the Lake District National Park Partnership, which has established a 'carbon budget' process to measure, manage and reduce carbon emissions across the National Park (www.lakedistrict.gov.uk/carbonbudget)

6 Appendix A: Methodology

6.1 The 'footprint' of consumption

In this report we use the term 'footprint' to mean the sum of the direct and indirect emissions that arise throughout supply chains of activities and products. As an example, the footprint of vehicle travel includes not only the direct vehicle emissions as covered by emissions factors issued by Defra[10], but also components for the extraction, shipping, refining and distribution of fuel, and components for the manufacture and maintenance of vehicles, and so on. Thus, in the case of car travel the final figure is typically around double that of the exhaust pipe emissions. To provide a further example, the footprint of electricity consumption includes components for the emissions associated with fossil fuel extraction, shipping, refining and transport to power stations, as well as those resulting from the electricity generation process itself. It is worth noting that the supply chain components are not included in standard conversion factors issued in Defra's *'Guidelines for Company Reporting on GHG Emissions'* (2011) and are accounted for using Environmental Input–Output methods (EIO) (See 6.5.1 Environmental Input–Output analysis (EIO) for details).

This inclusive treatment of supply chain emissions differs from more standard production-based assessments but gives a more complete and realistic view of impacts, despite the complexities and uncertainties involved. Footprints of this kind are essential metrics for responsible management.

6.2 Boundaries

6.2.1 Residents footprint

The following is within the scope:

- fuel and electricity consumed in homes,
- all residents personal travel both within and outside Cumbria, including commuting,
- emissions from food and drink and other purchased goods and services,
- water supply, sewage and waste,
- healthcare,
- education,
- other public services whether delivered at a local or national level,
- construction, maintenance and improvement of dwellings,
- the supply chains of all the above (e.g. fuel supply chains and embodied emissions).

The following is specifically excluded from the scope:

- business emissions including business travel (except in so far as the business output is consumed by residents).

6.2.2 Visitors footprint

The boundaries for the visitor footprint are the same as for residents and include both travel to and from Cumbria and travel during their visit.

6.2.3 Industry footprints

The following is within the scope:

10 Defra, 2011.

- direct emissions,
- electricity,
- travel and transport,
- emissions from purchased goods and services,
- fixed capital formation,
- the supply chains of all the above (e.g. fuel supply chains and embodied emissions).

The following is specifically excluded from the scope:

- commuting,
- emissions from staff activity outside the workplace.

6.3 Greenhouse Gas Protocol guidelines

The assessment follows the reporting principles of the GGP published by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI)[11].

We therefore cover all the gases specified in the GHG Protocol (GGP) expressed in terms of carbon dioxide equivalent (CO_2e), the sum of the weights of each gas emitted multiplied by their global warming potential (GWP) relative to carbon dioxide over a 100 year period.

The GGP provides three choices for emissions reporting. Scope 1 covers direct emissions from company-owned vehicles and facilities. Scope 2 includes net emissions from energy imports and exports, such as electricity. Scope 3 includes other indirect emissions resulting from company activities, as detailed by the boundaries of the study. This report includes all Scope 1 and 2 emissions and comprehensive treatment of Scope 3 supply chain emissions within the boundaries laid out above.

6.4 Treatment of high-altitude emissions

High-altitude emissions from aircraft are known to have a higher global warming impact than would be caused by burning the equivalent fuel at ground level. Although the science is still poorly understood, we have applied an emissions weighting factor of 1.9 to aircraft emissions, to accommodate this. This is the figure suggested in Defra's *Guidelines for company reporting on greenhouse gas Emissions*[12]. The figure can also be inferred from the Intergovernmental Panel on Climate Change's *Fourth Assessment Review*[13].

6.5 Reporting approach

The start point for this work is a model of GHG emissions *per capita* from UK consumption. For this we used an environmental input–output model (EIO) based on 2010 ONS '*Combined supply and use tables'* and *'UK environmental accounts'*. The specific model used was developed by Small World Consulting with Lancaster University (see below). The categorisation of emissions into 124 consumption categories was simplified into a 15 category model.

The methodology draws upon and combines two basic approaches:

11 Ranganathan et al., 2006.

12 Defra, 2011; more recently DECC has published supply chain emissions factors for energy use. We have not used these since they include only certain parts of the supply chains.

13 IPCC, 2007.

- Use of 'bottom up' data, where available, to estimate consumption, combined with emissions factors to estimate the associated emissions.
- Use of 'top down' macro-economic modelling; Environmental Input–Output analysis (EIO).

A first approximation of the emissions from each consumption category was obtained by multiplying the population of each District by a general figure for the average UK resident derived from 'top down' EIO (see section 6.5.1). We then improved upon our first estimate through a series of adjustments wherever available data provided a reasonable basis for doing so based on local data (normalised *per capita* to the national average) and plausible assumptions. These data sets and assumptions are detailed in section 6.6.

6.5.1 Environmental Input–Output analysis (EIO)

EIO combines economic information about the trade between industrial sectors with environmental information about the emissions arising directly from those sectors to produce estimates of the emissions per unit of output from each sector. The central technique is well established and documented[14]. In the UK, the main data sources are the *'Combined Supply and Use Matrix for 123 sectors'* and the *'UK environmental accounts'*[15], both provided by the Office of National Statistics (ONS).

The specific model used for this project was developed by Small World Consulting with Lancaster University and is described in detail below and elsewhere[16]. This model takes account of such factors as the impact of high altitude emissions that are not factored into the environmental accounts and the effect of imports. In order to use more up to date (2008 rather than 1995) data, we have employed a simple algorithm for converting between basic and purchasers prices. We have used consumer industry specific consumer price indices to adjust for price changes since the date to which the supply and use tables relate.

Three main advantages of EIO over more traditional process-based life-cycle analysis (LCA) approaches to GHG footprinting are worth noting:

EIO attributes all the emissions in the economy to final consumption. Although, as with process-based LCA, there may be inaccuracies in the ways in which it does this, it does not suffer from the systematic underestimation (truncation error) that process-based LCAs incur through their inability to trace every pathway in the supply chains[17].
EIO has at its root a transparently impartial process for the calculation of emissions factors per unit of expenditure, whereas process-based LCA approaches entail subjective judgements over the setting of boundaries and the selection of secondary conversion factors.
Through EIO, it is possible to make estimates of the footprints resulting from complex activities such as the purchase of intangible services that LCAs struggle to take into account.

One of the limitations of EIO in its most basic form is that it assumes that the demands placed upon (and therefore the direct emissions from) other sectors by a unit of output within one sector are homogeneous. As an example, a basic EIO model does not take account of the carbon efficiencies that

14 for example Leontief, 1986; Miller & Blair, 2009
15 ONS, 2010a; ONS, 2010b
16 Berners-Lee et al. 2011
17 Lenzen, 2001; Nässén et al, 2007

may arise from switching the expenditure on paper from a virgin source to a renewable source without reducing the actual spend. In this report, the carbon intensity per unit turnover of, for example, the hotels, pubs and catering establishments of Cumbria are assumed to be 'UK typical'. It is possible, with additional resource, to make bespoke adjustments to these generalities given relevant local data and a defendable basis for relating that data to emissions. A further assumption in the model used here is that goods from overseas are produced with the same carbon efficiency as they would have been in the UK. Overall, this assumption usually results in an underestimation of the footprint of purchased goods. A further omission for this and all EIO models that we are aware of is that the impact of land-use change around the world has not been taken into account. This would be likely to result in an increased assessment of the footprint of foods, especially animal products[18].

6.5.2 EIO methodology detail

The specific methodology and sources underpinning our model are outlined below in steps, along with some brief discussion.

Throughout the following matrices and vectors are written in capitalized bold font, while the individual elements of a matrix are denoted by the small cap of the name of the matrix and are not bolded. The operations in equations involving matrix or vector elements are standard mathematical operations while those in equations involving matrices are the corresponding matrix operations.

Step 1: A technical coefficients matrix of inputs from each sector per unit output of each sector (**A**) has been derived from an update to the UK Input–Output Analyses 2010 edition, Table 3 'Demand for products in 2008 Combined Use Matrix', based on 2008 data and obtained from the ONS[19]. (The ONS publishes on only 93 sectors for 2007, but released to us a 123 sector breakdown of 'unbalanced' figures. We used these judging that the benefit of disaggregation outweighs the risks from not going through the balancing process. Encouragingly, the disaggregated data set was in line with estimates based on extrapolation from the 2008 data set.) This matrix deals with the UK economy broken down into 123 industry groups. The process assumes that the output stimulated in each sector per unit demand at purchaser's prices is homogeneous and independent of the purchaser.

The matrix is usually derived from use tables of inputs at basic prices, which are output prices before distributers' margins, taxes or subsidies have been applied. However, for the UK these have not been published since 1995. By using purchasers' prices rather than basic prices to determine the technical input coefficients more recent data from 2008 data can be used rather than 1995 data. The trade-off is that it entails the assumption that demand at purchasers prices (including taxes, subsidies and distributors margins) is as good a guide to industry activity as demand at basic prices. Both of these values are surrogates for the stimulation of emissions-causing activity.

Step 2: Gross fixed capital formation is reallocated from final demand to intermediate demand, since the ongoing formation of capital is required to support the supply of goods and services, and is therefore instrumental in enabling the production of goods and services.

18 Audsley et al. 2010; This report estimates that emissions from red meat production outside Europe rises by a factor around five when land-use change is taken into account.

19 ONS, 2010a

Step 3: The Leontief inverse (**L**) of the technical coefficients matrix consists of a matrix of sectoral output coefficients as stimulated per unit final demand, all at basic prices.

$$L = (I-A)^{-1} \qquad \textbf{Equation 1}$$

Where **I** is the identity matrix.

Step 4: The UK Environmental Accounts[20] give the GHG emissions in 2008 arising directly from 93 SIC (Standard Industrial Code) sectors. These are mapped onto the 123 ONS IO Table industry groups by a process of splitting out SIC code emissions into IO industry groups in proportion to total output at basic prices and where necessary combining SIC codes into single Input–Output industry groups.

Step 5: Emissions from aviation at altitude are known to have a higher impact than the same emission at ground level. An emissions weighting factor of 1.9 was applied to the CO_2 emissions associated with the air transport sector to reflect additional radiative forcing per unit of GHG emitted. This simple mark-up factor is the figure proposed by Defra[21], based on the IPCC's discussion of aviation in its Fourth Assessment Report[22]. The application of this multiplier provides a first approximation to the impact of a complex and as yet poorly understood set of scientific phenomena surrounding aviation emissions.

Step 6: UK output by sector at basic prices[23] was combined with UK GHG emissions arising directly from each sector to derive a vector of coefficients of emissions per unit (£) of UK output from each sector at basic prices ($\mathbf{G}_{\mathbf{UK}}$). This is the vector of GHG intensity of each sector per unit financial output.

For each industry,

$$g_{UK_i} = e_{D_i} / o_{BP_i} \quad \text{i = 1 to 123 (industrial sectors)} \qquad \textbf{Equation 2}$$

where $\mathbf{O_{BP}}$ is the vector of UK sector-specific output at basic prices and $\mathbf{E_D}$ is the vector of sector specific direct emissions.

Step 7: The matrix (**E**) of GHG emissions arising from each industry (i) per unit of final demand for each industry (j) at 2008 basic prices is calculated as:

$$e_{ij} = l_{ij}.g_i \quad \text{i= 1 to 123 (industries), j= 1 to 123 (industries)} \quad \textbf{Equation 3}$$

Emissions intensity matrices based on different levels of import from within and beyond the EU can be constructed. In particular, we can substitute for g_i in the above equation to explore emissions intensities that might result where supply chains are typical of UK supply ($\mathbf{G_{UK\ Mix}}$), are based solely in the UK ($\mathbf{G_{UK}}$), solely in the EU ($\mathbf{G_{EU}}$), or solely outside the EU ($\mathbf{G_{Non\ EU}}$).

Step 8: Total emissions from each industry (i) arising from UK final demand for each industry (j) is given by

20 ONS, 2010b
21 Defra 2010a
22 IPCC, 2007
23 ONS, 2010a

$$e_{Total_{ij}} = e_{ij}.f_{BP_j} \qquad \textbf{Equation 4}$$

Where $\mathbf{E_{Total}}$ is the matrix of total emissions from each sector arising from final demand for each sector, and $\mathbf{F_{BP}}$ is the vector of final demand at 2008 UK basic prices.

Note that $\mathbf{F_{BP}}$ includes exports. To understand the impact of UK final demand, emissions from exports can be subtracted from each sector on a proportional basis.

Step 9: To obtain $\mathbf{F_{BP}}$, the final demand at purchasers' prices is adjusted by subtracting distributors margins taxes and subsidies, based on the assumption that these are split between domestic outputs at basic prices and imported products in the ratio of their respective monetary values

For industry i,

$$f_{BP_i} = f_{PP_i} - (d_i + t_i - s_i).(o_{BP_i}/(o_{BP_i} + b_i)) \qquad \textbf{Equation 5}$$

Where:

$\mathbf{F_{BP}}$ = Final demand at Basic Prices,

$\mathbf{F_{PP}}$ = Final Demand at Purchasers prices and

D,T,S, O_{BP} and **B** are the vectors of distributors' margins, taxes, subsidies, total output at basic prices and imports respectively.

A key assumption here is that distributor's margins, tax and subsidies are applied to domestic production and imports at the same rates, and can therefore be apportioned according to monetary value.

The data are obtained from Tables 2 and 3 in the UK Input–Output Analysis Tables[24].

Step 10: This step converts emissions factors from basic prices to purchasers' prices**.** The majority of this conversion is done simply by dividing by the ratio of final demands at purchasers and basic prices. However, there remains the question of allocating emissions arising from distribution services to the sectors whose products use those sectors.

In the UK IO tables, three distributor sectors require special treatment, since the products they deal with are not counted as inputs and only the marginal increase in their value is counted as outputs for those sectors. These sectors are 'Motor vehicle distributors', 'Wholesalers' and 'Retail'. The emissions associated with these three sectors have been aggregated and redistributed between the industries they serve in proportion to the distributor's margins that are associated with their products.

The core assumption here is that emissions arising from distribution services are in proportion to the margins they generate for the products of each other industry.

24 ONS, 2010a

6.6 Adjustments based on bespoke national and local data

The result based on EIO and UK averages was then adjusted to take account of key differences in consumption patterns for both visitors and residents from the UK average, wherever available data provided a reasonable basis for doing so. Estimates were also added for visitor travel to and from Cumbria. Specifically, the following adjustments were made.

6.6.1 Estimating residents consumption

Household energy

Consumption of household fuel and electricity in each District was taken from DECC's sub-regional energy data sets[25].

Personal air travel

Bespoke data in resident flight habits exists[26] however was beyond the budget for this report, without it there was no basis to assume than Cumbria residents flight habits differ substantially from UK average, therefore no adjustment was made.

Household goods and services

Household income deciles[27] for each District were used to model the proportion of residents within each UK income decile. Expenditure on household foods, goods and services by each UK income decile as a proportion of the UK average was derived from UK household expenditure survey and Defra's 'Family Food Survey'[28]. In this way expenditure *per capita* as a ratio of the UK average was derived for each District/Borough.

Food

The family food survey[29] profiles consumption of food types against income deciles and we mapped this against the carbon footprint of food types based on Small World Consulting's model of the carbon in food categories at Booths Supermarkets[30].

Vehicles and vehicle fuel

As with household goods and services, family expenditure on personal motor vehicles and motor vehicle fuel by each UK income decile as a proportion of the UK average was derived from UK household expenditure survey[31]. In this way expenditure *per capita* as a ratio of the UK average was derived for each District.

6.7 Estimating visitors consumption

6.7.1 Visitor travel from over seas

Data for visitors arriving from overseas by plane, ferry or the channel tunnel was obtained from Cumbria Tourism's 2010 *'International Visitor Survey'* which provided data on the proportions of overseas visitors arriving by mode and country of origin. These were combined with estimates on overseas visitor numbers attained by combining estimates for the proportion of day and staying visitors from overseas

25 DECC,2009a,b&c
26 CAA, 2011
27 ONS[c], 2010
28 ONS[d], 2010; Defra, 2010b
29 Defra, 2010b
30 Booths, 2010
31 ONS, 2010d;

from Cumbria Tourisms 2009 *Visitor Survey* with STEAM 2010 estimates for visitor numbers to estimate the total emissions resulting from arrival from overseas.

Estimates of time spend in Cumbria were divided by estimates of the length of overseas visitor trips to give the proportion of each journey to the UK that should allocated to Cumbria visit. ONS Travel and Tourism data[32] gave information leading to estimates of the average length of stay in the UK by visitors from different parts of the world (Europe, North America and 'Other') and estimates of the lengths of stay in Cumbria came from the Cumbria Tourism 2009 *Visitor Survey*.

6.7.2 Visitor travel within the UK

Data on visitor travel within the UK, including both travel to and from Cumbria and travel during their stay was obtained from survey data from the Lake District National Park Authority was used to model average journey distances, group size and mode of travel which were combined to estimate the emissions from all other visitor travel.

6.7.3 Consumption of goods and services

Consumption of accommodation, food and drink, leisure and recreation activities and other purchased goods and services were estimated from expenditure, using data from the Cumbria Tourism visitor surveys (2009).

Some types of goods and services were assumed not to be bought or directly consumed by visitors, for example domestic appliances and education.

6.8 Uncertainties

The complexity of supply chains and the difficulties in obtaining accurate data dictate that footprinting can only offer a best estimate rather than an exact measure, and the figures in this report should be viewed in that context. We have operated from the principle that it is more informative to make best estimates of even the most poorly understood components of the footprint, and to discuss the uncertainty openly, than to omit them from the analysis.

Overall, the results in this report should be viewed as offering a broad guide to the size and relative significance of different components

6.8.1 Uncertainties over data

The assumptions made to estimate the residents' footprint relies largely on national surveys of household expenditure[33]. Sample sizes for both these are high and statistical techniques have been used to represent populations. However, the surveys rely on self reporting.

Sub-regional energy consumption estimates from DECC[34] are probably high enough quality not to contribute significantly to the overall uncertainty.

Available industry data was somewhat sparse and we had to fall back on Office of National Statistics' regional accounts, breaking down into just ten categories.

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[32] ONS, 2010[e].

[33] Defra, 2010[b]; ONS[c], 2010

[34] DECC, 2009[a,b&c]

For the carbon footprint of visitors there is a far greater level of uncertainty, much of the data was drawn from visitor surveys, in which responses may have been systematically inaccurate, the sample group not fully representative and sample sizes were not always ideal.

6.8.2 Uncertainties over conversion factors

The areas in which the relationship between consumption and footprints is best understood are gas and electricity consumption. There is relatively good consensus over conversion factors to within around 5% in these areas. The next most certain group of conversion factors are those for travel and transport. In this category, there is uncertainty over the impact of high altitude emissions and the embodied emissions in the manufacture and maintenance of vehicles, roads and other infrastructure.

Supplies and services are the areas of greatest uncertainty. As an example, credible process based life cycle analyses of a particular specification of paper typically differ by factors of around 50% depending on the specific practices employed in the particular mill in which it was manufactured. It would also be possible for two detailed studies of exactly the same process to arrive at significantly different estimates, depending on the precise assumptions made. The EIO approach that we have adopted overcomes the truncation error that process-based approaches incur, but does suffer its own series of problems, most notably errors of generalisation – the failure to look at the particular circumstances of a supply chain rather than an industry average.

6.8.3 Other modelling uncertainties

The use of local data to make adjustments from UK averages has involved a series of judgements in consultation with academics and others. The modelling itself has required complex calculations. Despite careful checking of formulae and sense checking of results, the possibility of human error can never be wholly eliminated.

7 Appendix B: Sources

Source	Web link
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Berners-Lee, M. Howard, D.C. Moss, J. Kaivanto, K. Scott, W.A. (2011) 'GHG footprinting for small businesses - The use of input–output data'. Science of The Total Environment, 409(5):883-891.	
Booths, 2010, The GHG Footprint of Booths. A report by Small World Consulting Ltd.	http://www.booths.co.uk/Documents/Booths_Full_Report_100720.pdf
Cumbria Tourism 2009, 'Tourism Volume and Value 2000 – 2009', (Produced by STEAM)	Available for purchase from Cumbria Tourism
Cumbria Tourism, 2009 Visitor Survey	Available for purchase from Cumbria Tourism
Cumbria Tourism, 2010, International Visitor Survey	Available for purchase from Cumbria Tourism
DECCa Sub-national estimates of non gas, non electricity and non road transport fuels 2005, 2006, 2007 and 2008	http://www.decc.gov.uk/en/content/cms/statistics/regional/other/other.aspx
DECCb Sub-national gas consumption statistics 2009	http://www.decc.gov.uk/en/content/cms/statistics/regional/gas/gas.aspx
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ONS (Office of National Statistics), 2010[c]Annual Survey of Hours & Earnings (ASHE)	http://www.statistics.gov.uk/pdfdir/ashe1210.pdf
ONS (Office of National Statistics), 2010[d] Family Spending 2010 (Living Costs and Food Survey 2009)	http://www.statistics.gov.uk/downloads/theme_social/familyspending2010.pdf
Office of National Statistics, 2010[e], Transport Travel and Tourism 1999 - 2010 Overseas Travel & Tourism. Tables 1 and 6.	http://www.statistics.gov.uk/
UNFCCC, 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change. Kyoto: United Nations	
WRAP (2008) 'The Food We Waste' Waster & Resources Action Programme (WRAP), Banbury. Available on request at	http://www.wrap.org.uk/retail_supply_chain/research_tools/research/report_household.html

[i] In this note, the term 'carbon' is used as a shorthand for carbon dioxide and other greenhouse gases

[ii] For a summary of the science on climate change, see the briefing produced for MPs, *Climate Science Explained*, Green Alliance and Imperial College London

http://www.green-alliance.org.uk/grea_p.aspx?id=5917

[iii] For details of LGA work in this area see http://www.local.gov.uk/web/guest/the-lga-and-climate-change/-/journal_content/56/10171/3574359/ARTICLE-TEMPLATE

[iv]House of Commons Energy and Climate Change Committee, Consumption Based Emissions Reporting, April 2012

[v] In this note, the term 'carbon' is used as a shorthand for carbon dioxide and other greenhouse gases

[vi] For a summary of the science on climate change, see the briefing produced for MPs, *Climate Science Explained*, Green Alliance and Imperial College London

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[vii] Committee on Climate Change, How local authorities can reduce emissions and manage climate risks,

[viii] For details of LGA work in this area see http://www.local.gov.uk/web/guest/the-lga-and-climate-change/-/journal_content/56/10171/3574359/ARTICLE-TEMPLATE

[ix]House of Commons Energy and Climate Change Committee, Consumption Based Emissions Reporting, April 2012