3 Consumption of Goods and Services in the South East

3.1 Introduction to the Methodology

3.1.1 Consumption of goods in the South East

The production of goods takes place so we can consume, therefore all energy use in an economy can be allocated to consumption. The main consumption sector is formed by households. Households have many categories of expenditures: they buy products (food, clothes, etc.) and use services (insurance, public transport, etc.).

The whole economy is based on this consumption of goods produced by industry and services delivered by the service industry. The direct energy use of the production sectors can be considered as indirect energy use of the households (Wilting 1999[1]). Thus households do not only use direct energy, e.g. electricity, motor fuels and natural gas, but also indirect energy by purchasing goods and services. The total energy use of households, direct and indirect, can be described as the "Household Metabolism" (Noorman and Uiterkamp 1998)[2].

This chapter describes the methods employed and the results derived from calculating the "Household Metabolism" of residents in the South East. The methodology can be broken down into two main categories: the efficiency of production per tonne and the total tonnage of consumption (for details of the underlying approach see Chapter 1).

The conversion factor for the material flow analysis and ecological footprint are both measures of the efficiency with which the resources are utilised (i.e. a measure of technological performance). This allows improvements in technology to become a responsive variable within the equation. The tonnage of over 100 consumer items within the household becomes another variable that responds to changing consumer behaviour and lifestyle choices.

This provides a clear picture of the global ecological impact households in the South East are responsible for, and the options for reducing this impact based on eco-efficiency measures or changes in consumption levels. This section combines both indirect and direct energy and material requirements. The direct energy requirements consider electricity and gas consumption and passenger transport, while the indirect energy and material consumption considers a comprehensive range of materials consumed by households in the South East.

This chapter has been structured using policy significant components allowing the reader to select the component which has most relevance to them. These include transport, food, aggregates and construction, water and energy. Within each of these sections the impact of direct consumption and the consumption of products through services has been defined.

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[1] Wilting HC (1999) Analyzing Potentials for Reducing the Energy Requirement of Households in The Netherlands. *Journal of the International Input–Output Association* (Economic Systems Research), 11(3): 233-244

[2] Noorman KJ, Uiterkamp TS (1998) *Green Households? Domestic Consumers, Environment and Sustainability*. Earthscan, London

Data sources

In order to accurately gauge household metabolism in the South East, a number of different methods were applied and a variety of data sources used. These are described in the list below.

The Office of National Statistics (ONS), together with other Government departments, undertake a range of surveys that investigate consumption by region (for example the National Food Survey). These surveys provide valuable data that give a key insight into consumption patterns of a given population. As they are produced by ONS it is also possible to rely on the statistical robustness of the results, or at least understand the error margins involved. Finally, the advantage of using these surveys is that they are produced annually allowing comparisons and trends over time to be explored.

Socio-demographic understanding of consumption

Not all of the necessary data are directly available from regional databases or surveys. This means that a modelling approach needs to be adopted that provides the best possible method for understanding consumption patterns. The modelling approach relies on a range of socio-demographic and expenditure data (for example the Family Expenditure Survey from ONS).

National datasets

National datasets have been used as a reference baseline, to provide an understanding of the accuracy of the data and also to provide data for the modelling approach. A number of key datasets have been used including PRODCOM, UK Trade data, and Transport Statistics.

Locally specific data

In some cases, locally specific data have been obtained. These data can act as accurate input data into the model or as data to verify the modelling approach. The concern with using locally specific data is the difficulty of repeating the study or relying on its statistical accuracy. Therefore, the data are mainly used to verify the overall approach.

The issue of double counting has been taken very seriously and a number of approaches have been adopted to prevent this from happening. One of the problems is that the results can be divided in a number of different ways, meaning that a particular component could appear in two or three sections. For example, the section of passenger transport includes the impact of air travel and so does the following section that considers the impact of holidays. Another example is packaging that appears as a basic material input (e.g. metals or plastics) and as an output (waste).

Therefore, it is not possible to add up all the figures that appear through the report and derive a total material flow analysis or ecological footprint. However, Chapter 6 has considered these issues and shows a total material flow analysis and ecological footprint of the South East that takes into account double counting.

The development of satellite accounts

The focus of this report is on the consumption of goods and services by South East residents employing the methodologies of material flow analysis and ecological footprint. However, these two methodologies do not provide useful information on the environmental impact of production. Therefore in Chapter 5, an attempt is made to quantify the environmental impact of the production of these goods and services within the South East.

3.1.2 Consumption of services in the South East

Services such as healthcare, leisure activities, travel (home and abroad), education and communication contribute to the quality of life of South East residents. Material consumption can be attributed to each of these services. As the demand for services increases so does the consumption of the service sector. This section explores the material consumption, energy demand and subsequent pollution associated with the service sector within the South East.

The development of the service economy

One of the key features of the UK economy over the past two years has been the increasing performance of the service sector (the last 30 years have seen a growth rate of 2.6 percent per year) (Julius 2002)[3]. The rate of output growth in the service sector has been more than double that of manufacturing. Services now account for two thirds of UK GDP, and three quarters of employees are engaged in providing services (Julius 2002). There is evidence to suggest a fundamental shift from the sale of material goods to the provision of services. Therefore, the principal role of the economy is not the provider of goods but a provider of services (Jackson 1996)[4]. The service sector, as defined by ONS, corresponds to the non-tangible, non-commodity notion – everything except agriculture, mining, construction and manufacturing. ONS define the four basic categories, as set out in the national accounts, as: distribution, hotels and catering (DHC); transport and communications (T & C); finance, real estate and business services (FRB); and government and other services (GOV). These form the categories of this section.

Figure 3.1 shows the material dimensions associated with the provision of services. The growth in waste generation by the services sector is a clear signal of both increased demand for services and higher levels of consumption.

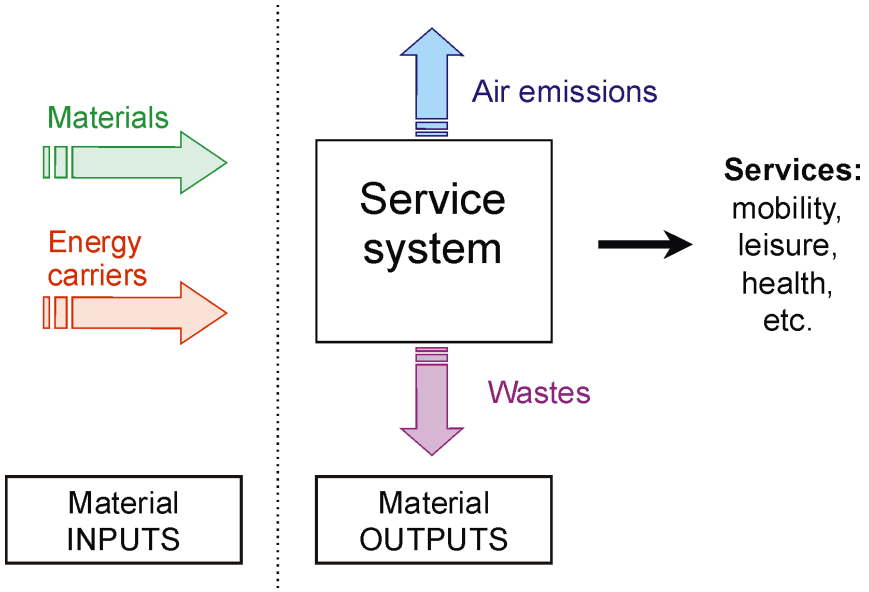

Figure 3.1 Material dimensions associated with the provision of services (adapted from Jackson 1996[5])

[3] DeAnne Julius (1998) Inflation and growth in a service economy, *Bank of England Quarterly Bulletin*, November 1998, 338-346
[4] Jackson T (1996) *Material Concerns – Pollution, profit and quality of life*. Stockholm Environment Institute, Routledge, London
[5] Jackson T (1996) *Material Concerns – Pollution, profit and quality of life*. Stockholm Environment Institute; Routledge, London

Methodological approach

The overall approach adopted to analyse the resource and energy consumption of the service sector can be described as a hybrid Economic Input-Output approach. The analysis relies on a set of national accounts produced by ONS. These include the "Blue Book" (Economic Input-Output Table for the UK) and PRODCOM (PRODucts of the European COMmunity). This is the common basis by which industrial production statistics are collected throughout the European Union. The SEI Embodied Energy Database[6] was also employed to calculate the energy component of the material flow analysis. Finally, the Family Spending Survey, produced by ONS, was used to provide a meaningful method by which to assess the consumption of services by South East residents. In addition to ONS data, UK consumption data of key products were taken from industry reports. For example, The Paper Federation of Great Britain produces a comprehensive publication entitled "Reference Statistics". This provides valuable data for the UK's consumption of paper and paper products and fills many gaps that exist within PRODCOM.

The use of "Economic Input-Output Tables"

The Input-Output (I-O) framework breaks the economy down to display transactions of all goods and services between industries and final consumers in the UK for one year (ONS 2002)[7] (see Box 3.1 for further details). In this study I-O tables have been used to provide an understanding of the transactions between industries' intermediate consumption by service sector providers; for example, the demand for paper that is made by finance and banking. However, included within the expenditure data is expenditure on taxation and labour. This has to be removed from the calculation to provide a more precise indicator of the expenditure between the two industries. The I-O Tables are structured around the "Standard Industrial Classification" (SIC). SIC is used to classify business establishments and other statistical units by the type of economic activity in which they are engaged. The present (1992) revision is based on the activity classification issued by the Statistical Office of the European Communities (Eurostat), known as the NACE[8] classification.

Box 3.1 Background Information of Economic Input-Output Tables

The Input-Output (I-O) framework breaks the economy down to display transactions of all goods and services between industries and final consumers in the UK for one year. Information is presented in two key products: Annual Input-Output Supply and Use Tables (I-O SUTs), and Input-Output Analytical Tables (I-O ATs). The I-O SUTs show the whole economy by 123 industries (e.g. motor vehicles industry) and 123 products (e.g. sports goods). The tables show links between components of gross value added, industry inputs and outputs, product supply and demand. The I-O SUTs link different sectors of the economy (for example public corporations) together with detail of imports and exports of goods and services, government expenditure, household expenditure and capital investment.

I-O Tables show separately the consumption of domestically produced and imported goods and services, providing a theoretical framework for further structural analysis of the economy, the composition and the effect of changes in final demand on the economy. The I-O work also plays a central role feeding into many key ONS items such as chain-linking the production measure of GDP, Producer Price Indices, Regional Accounts and Environmental Accounts.

[6] The SEI Embodied Energy Database refers to a collection of information from a multitude of sources concerning the energy required to produce materials and products. The database has over 6,000 entries and provides the basis for an energy analysis.

[7] Office for National Statistics (2002) UK National Accounts (The Blue Book), *Blue Book* 2002 Edition, http://www.statistics.gov.uk/statbase/Product.asp?vlnk=1143&More=N
and http://www.statistics.gov.uk/downloads/theme_economy/BB_2002.pdf

[8] NACE is the Classification of Economic Activities in the European Community

The use of "PRODCOM"

PRODCOM covers some 4,800 products which in the UK are assigned to some 250 industries (subclasses) as defined by the 1992 Standard Industrial Classification SIC(92). Some 200 industries are surveyed annually with the remaining 50 being surveyed on a quarterly basis. The PRODCOM data are collected through a series of surveys by The Office for National Statistics (ONS). The trade data (exports and imports) are collected by HM Customs and Excise and measure the flow of goods into and out of the UK.

Total exports and imports are broken down into intra- and extra- EC trade, i.e. trade with members of the EC, and trade with countries outside the EC. Intra-EC trade data are collected by INTRASTAT, a survey-based system operated by Customs covering the largest traders. Extra-EC trade data are collected from information given on Customs documentation which has to accompany goods passing through border controls. It should be recognised that there are many gaps within PRODCOM due to either the data being suppressed for confidentiality reasons or not being available.

The use of the "Family Spending Survey"

In an attempt to allocate the consumption of the service sector to the South East residents, a method has been derived that realistically apportions the national consumption. The "Family Spending Survey" (FSS) has been employed to conduct this analysis. FSS provides information concerning the expenditure of different services within the different Government Office Regions, the South East being one of these. Using this information, the demands that the South East places on the different service sectors can be quantified and compared with those of the UK as a whole. Thus, the varying levels of demand for each service have been allocated to the South East using this approach. As with the I/O table, issues of taxation and labour have been taken into account. Examples of the calculations can be seen in the various sections below. Issues of double counting have also been taken into account.

3.2 Passenger Transport

In order to provide a comprehensive assessment of the environmental impacts of passenger transport in the South East, a three step analysis was undertaken. Firstly, South East-specific data on all passenger transport modes was gathered, derived and compiled. This was followed by an analysis of the total flow of materials associated with travelling. Finally, the ecological footprint methodology was used to calculate the environmental impact of travelling by South East residents.

This chapter also includes an analysis of the environmental impacts of holidays undertaken by South East residents due to the fact that travelling to a holiday destination comprises the largest part of the ecological footprint (EF) of holidays.

3.2.1 Compilation of passenger transport data in the South East

The analysis of passenger transport modes used by South East residents included travelling by air, bicycle, car/van, local bus and coach, motorcycle, taxi and train. Walking was included in the compilation of data but excluded from further analysis as the environmental impact of walking is negligible.

For each mode the passenger-kilometres (pkm) travelled by South East residents were calculated using regional and national data for the year 2000. South East specific data were provided by ONS/DfT for travel by bicycle, car, bus, coach, motorcycles and train. For air travel, data on passenger-kilometres travelled by UK residents were used. As a proxy for missing South East-specific data these numbers were multiplied by a factor of 1.75 as household expenditure on international air travel is 1.75 times higher in the South East than the UK average (UK Department for Transport, Focus on Personal Travel 2001 and National Travel Survey 2001). The following table lists the results of passenger transport data specific to the South East.

Table 3.2.1 Average distances and total passenger-kilometres travelled by South East residents in the year 2000 by different modes of transport.

Mode of transport	Average distance travelled per person [km]	Total passenger-kilometres by all SE residents [billion (10^9) pkm]
Air travel - all services	**7,634**	**62.0**
… of which total international	***7,411***	***60.1***
… of which total domestic	***224***	***1.81***
… intra EU-15 (1999)*	***1,368***	***11.1***
Walking (including short walks)	**303**	**2.46**
Bicycle	**74**	**0.600**
Private hire bus	**69**	**0.562**
Car	**11,166**	**90.6**
… of which petrol cars	***9,701***	***78.7***
… of which diesel cars	***1,455***	***11.8***
>>> car driver	***7,376***	***59.9***
… of which petrol cars	***6,408***	***52.0***
… of which diesel cars	***961***	***7.80***
>>> car passenger	***3,790***	***30.8***
… of which petrol cars	***3,293***	***26.7***
… of which diesel cars	***494***	***4.01***
Motorcycle/moped	**19**	**0.157**
Van/lorry	**139**	**1.13**

Mode of transport	Average distance travelled per person [km]	Total passenger-kilometres by all SE residents [billion (10^9) pkm]
… of which petrol vans	***112***	***0.909***
… of which diesel vans	***27***	***0.218***
Other private (including invalid carriages, dormobiles, etc.)	**17**	**0.137**
Local bus	**224**	**1.82**
Non-local bus	**118**	**0.961**
Surface rail	**824**	**6.69**
Taxi/minicab	**100**	**0.812**
Other public (including air, ferries, light rail, etc.)	**54**	**0.436**
All modes excl. air travel	**13,107**	
All modes incl. air travel	**20,741**	

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://europa.eu.int/comm/energy_transport/etif/transport_passenger_b/air_pkm.html)**

The average person in the South East region travelled 20,741 km in 2000 of which 11,166 km (54%) were undertaken by car and 7,634 km (37%) by aeroplane. All other modes of transport – mainly public transport – accounted for only 9% of the total distance travelled.

3.2.2 Total Material Flow Analysis of South East passenger transport

Data on direct fuel consumption and associated hidden flows of energy carriers, as well as the distance travelled, have been used to calculate the total material input flow of different transport modes. On the material output side, emissions of the greenhouse gases CO_2, CH_4 and N_2O were accounted for.

Except for air and rail transport, emission data and fuel consumption data were derived from the UK National Atmospheric Emissions Inventory (NAEI) which contains the UK Emission Factors Database (EFD)[9]. Fuel consumption of aeroplanes was derived from CO_2 emission data provided by DEFRA[10]. For passenger railway transport total energy carrier consumption was calculated on a passenger-kilometre basis using both direct fuel consumption and fuel consumption via electricity[11]. The share of consumption due to passenger transport, in contrast to freight transport, was derived from the proportion of CO_2 emissions allocated to each category according to emission factors given by DEFRA[10]. The 'hidden flow' factor for petroleum is 1.016 and for hard coal 4.87, i.e. for each tonne of petroleum 16 kg and for each tonne of hard coal 3.87 tonnes of additional material have to be moved[12].

Table 3.2.2 provides the results of the material flow analysis (MFA) for passenger transport by South East residents. A total of 6.3 million tonnes of fuel was required by South East passenger transport in 2000. This produced nearly 24 million tonnes of CO_2 emissions.

[9] http://www.naei.org.uk/emissions/index.php

[10] http://www.defra.gov.uk/environment/envrp/gas/10.htm

[11] Data from International Energy Agency (IEA), Statistics and Balances, 2001 edition

[12] Nigel Lawson, School of Geography, The University of Manchester. Update of Table 2 in: Douglas I and Lawson N (1997) An earth science approach to assessing the disturbance of the earth's surface by mining; *Mining and Environmental Research Network Research Bulletin*, 11-12, p. 37-43

Table 3.2.2 MFA of Passenger Transport in the South East

Mode of transport	Material Input [tonnes]				Material Output [tonnes]			
	Energy Carriers (Diesel, Petroleum)	Hidden Flows of energy carriers	Total MFA	Total MFA per capita	Total CO_2 Emissions	Total CH_4 Emissions	Total N_2O Emissions	Total GWP Emissions
	['000 tonnes]	['000 tonnes]	['000 tonnes]	[tonnes/cap]	['000 tonnes]	['000 tonnes CO_2 eq.]	['000 tonnes CO_2 eq.]	['000 tonnes CO_2 eq.]
Air travel - all services	2,449	39.2	2,488	0.3066	7,715	2.65	0.414	7,900
… of w. total international	*1,714*	*27.4*	*1,742*	*0.2146*	*5,400*	*2.45*	*0.326*	*5,553*
… of which total domestic	*104*	*1.66*	*105*	*0.0130*	*327*	*0.029*	*0.012*	*331*
*… intra EU-15 (1999)**	*631*	*10.1*	*641*	*0.0794*	*1,988*	*0.174*	*0.076*	*2,020*
Walking	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
Bicycle	0.0115	0.00018	0.0117	0.000001	0.036	0	0	0.036
Private hire bus	16	0.255	16.2	0.0020	72.0	0.0083	0.0014	73
Car	3,320	53.1	3,373	0.4156	14,930	1.23	1.161	15,318
… of which petrol cars	*2,993*	*47.9*	*3,041*	*0.3748*	*13,510*	*1.18*	*1.009*	*13,849*
… of which diesel cars	*326*	*5.22*	*331*	*0.0408*	*1,421*	*0.050*	*0.151*	*1,469*
>>> car driver	*2,193*	*35.1*	*2,228*	*0.2746*	*9,864*	*0.811*	*0.767*	*10,120*
… of which petrol cars	*1,977*	*31.6*	*2,009*	*0.2476*	*8,925*	*0.778*	*0.667*	*9,148*
… of which diesel cars	*216*	*3.45*	*219*	*0.0270*	*938*	*0.033*	*0.100*	*970*
>>> car passenger	*1,127*	*18.0*	*1,145*	*0.1411*	*5,068*	*0.417*	*0.394*	*5,199*
… of which petrol cars	*1,016*	*16.3*	*1,032*	*0.1272*	*4,586*	*0.400*	*0.343*	*4,701*
… of which diesel cars	*111*	*1.77*	*113*	*0.0139*	*482*	*0.017*	*0.051*	*498*
Motorcycle/moped	4.82	0.0771	4.90	0.0006	25.9	0.024	0.000	26.5
Van/lorry	40.6	0.650	41.3	0.0051	182	0.015	0.014	187
… of which petrol vans	*34.6*	*0.553*	*35.1*	*0.0043*	*156*	*0.014*	*0.012*	*160*
… of which diesel vans	*6.03*	*0.0965*	*6.13*	*0.0008*	*26.3*	*0.001*	*0.003*	*27.2*
Other private (including invalid carriages, dormobiles, etc.)	5.2	0.083	5.29	0.0007	23.5	0.002	0.002	24.1
Local bus	51.5	0.823	52.3	0.0064	233.0	0.027	0.005	235
Non-local bus	14.4	0.230	14.6	0.0018	62.7	0.007	0.002	63.3
Surface Rail	288.2	518	806	0.0994	401	0.011	0.153	449
Taxi/minicab	55.4	0.887	56.3	0.0069	246	0.016	0.022	253
Other public (including air, ferries, light rail, etc.)	12.3	0.198	12.5	0.0015	55.9	0.006	0.001	56.4
Total	6,257	614	6,871	0.847	23,950	4.000	1.78	24,584

3.2.3 Calculating the Ecological Footprint of South East passenger transport

a) Methodology

The ecological footprint of passenger transport combines a number of important activities that have an impact on the environment. These include:

- the direct emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the combustion of fuels;
- the emissions of carbon dioxide (CO_2) from the manufacture as well as the maintenance of vehicles; and
- the direct land use for transport (e.g. road space, car parks).

All these various impacts of transport are converted into a land figure. This is done for all forms of transport thus permitting different impacts of transport to be compared in the same terms, as well as allowing comparisons of the impact of different forms of transport. This provides a useful tool for policy decision-makers and planners.

The model described below is used to calculate the environmental impact of passenger transport in the South East. All the figures are based on the fact that transport requires land area in the form of built-up areas (e.g. roads, car parks) as well as the notional land area required for absorbing the carbon dioxide (CO_2) produced by the combustion of fuels (excluding the absorption by oceans). At present, the current carbon sequestration rate employed is estimated as being 5.2 tonnes of carbon dioxide per hectare of forest in one year (i.e. 1 tonne CO_2 requires 0.19 ha of forest of world-average productivity)[13]. The advantage of this methodology is that a land-based analogue of a real mechanism in the global carbon cycle is provided. However, adopting this approach does not mean that carbon sequestration is seen as the only solution to excessive emissions of carbon dioxide. As a matter of fact, with current emission rates of fossil CO_2 there is not enough land to provide humanity with all the necessary resources and to support the critical life-support functions of the planet such as the carbon balance. The only way to curb global warming is to reduce the overall amount of carbon dioxide from fossil fuels being released into the atmosphere.

To calculate the environmental impact of travel, data concerning the emissions of greenhouse gases, the energy requirements of manufacturing and maintenance, the fuel consumption and the land area occupied by roads are collected. An example of the ecological footprint calculation for passenger transport in the UK is given in Table 3.2.3. Here an average ecological footprint is derived for a single passenger-kilometre travelled by petrol car/light van. This average, together with similar averages for other modes of transport, is then used to calculate the impact of passenger transport in the South East according to the estimated modal distribution of annual passenger-kilometres travelled by South East residents.

[13] WWF (2002) *Living Planet Report 2002*; WWF International, Gland, Switzerland

Table 3.2.3 Derivation of the ecological footprint for UK petrol cars/light vans per passenger-kilometre travelled (adapted from Simmons et al. (2000)) [14]

	Emissions[a]	Global warming potential (GWP) as CO_2 equivalents[b]	Footprint per car-km (global hectares)	Footprint per passenger-km (global hectares)
Fuel combustion	184.7 g CO_2/car-km 0.023 g CH_4/car-km 0.020 g N_2O/car-km	191.3 g CO_2 eq. /car-km	0.00004950[c]	0.00003173[c]
Maintenance & manufacture[d]	83.1 g CO_2/car-km		0.00002150[c]	0.00001378[c]
Road space			0.00000002[e]	0.00000001[f]
Total Footprint			0.00007101	0.00004552

[a] UK National Atmospheric Emissions Inventory – UK Emission Factors Database (NAEI-EFD), http://www.naei.org.uk/emissions/index.php

[b] Global warming potential (GWP) factors used: 21 for CH_4 and 310 for N_2O (IPCC, TAR[15])

[c] Notional 'Energy Land' required to sequester CO_2 emissions assuming 5.2 tonnes CO_2 sequestered by 1 ha of forest and a global hectare equivalence factor for forest of 1.345[16]

[d] It is estimated that the equivalent of 15% of the fuel energy use is needed to manufacture and maintain a vehicle with an extra 30% for the construction and maintenance of the road infrastructure (Wackernagel and Rees 1996)[17]

[e] Assuming a total UK road space of 330,379 ha and a total annual distance of 467,700 million km travelled by UK road vehicles (DfT 2002)[18]

[f] Assuming average car occupancy of 1.56 persons (DTLR 2001)[19]

For petrol cars/vans, diesel cars/vans, buses, coaches and motorcycles, average emissions of CO_2, CH_4 and N_2O per vehicle kilometre were derived from the NAEI[20] Emission Factor Database (EFD). This database provides emission factors (per km) for a range of different pollutants, vehicles and types of roads used by the vehicle. It was decided to use this database as it is recognised by the UK Department for Transport (DfT) and local authorities as the most comprehensive collection of transport emission factors relevant to the UK. In this study, average emission factors for different types of roads (urban, rural single and dual carriageway and motorway) were calculated.

CO_2 emissions of trains and aeroplanes (short and long distances) were adopted from DEFRA[21] while their specific emissions of CH_4 and N_2O were derived from the NAEI-EFD.

The ecological footprint of greenhouse gas emissions is represented by the notional 'energy land' (forests) required to sequester the CO_2 emissions. 'Global equivalence factors' have been applied in this study in order to adjust specific land-use areas to land units of world-average productivity, termed

[14] Simmons, Lewis and Barrett (2000). Two feet – two approaches: a component-based model of ecological footprinting, *Ecological Economics*, Vol. 32., No.3., pp 375-380

[15] 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

[16] WWF (2002*) Living Planet Report 2002*; WWF International, Gland, Switzerland

[17] Wackernagel M., Rees W. (1996) *Our Ecological Footprint*, New Society Publications, CA.; Wackernagel M., Silverstein J. (2000) Big things first: focusing on the scale imperative with the ecological footprint*, Ecological Economics*, Vol.32, No.3, pp391-394.

[18] Department for Transport (2002) Transport Statistics Bulletin – ROAD TRAFFIC STATISTICS: *2001, Statistics Report* SB (02) 23; DfT, London

[19] DTLR (2001) *Focus on Personal Travel*; The Stationery Office, London

[20] UK National Atmospheric Emissions Inventory (NAEI)

[21] http://www.defra.gov.uk/environment/envrp/gas/10.htm

'global hectares'[22]. For 'energy land' (forests) the global equivalence factor is 1.35gha/ha which means that the forest land required to absorb the CO_2 is 1.35 times more productive than the world average for biologically productive land.

The ecological footprint of road traffic also includes the road space occupied by road vehicles. On a vehicle-km basis it is assumed that this road space is the same for all types of vehicle and is calculated as the total area of the UK road network (in ha) divided by the total distance travelled (in km) by all UK's road vehicles. As it is already a type of land (built land) this figure simply has to be converted into global hectares (assuming a global equivalence factor of 2.18) in order to convert it into a footprint figure. Built land area for railtracks and airports were estimated using data on the length of total railtracks and numbers of UK airports. Finally, the ecological footprint is converted from being expressed on a vehicle-km basis into a passenger-km basis by taking into account the average occupancy of the vehicle class (e.g. 1.56 for cars). The advantage of including vehicle occupancy in the calculations is that the higher the occupancy rate, the lower the impact per person using the vehicle. This makes it possible to consider three elements in the calculation:

- the ecological footprint can be calculated on an individual basis;
- the ecological footprint of car travel is not solely the impact of a particular car, but the shared impact of individuals;
- scenarios can be developed for reducing the ecological footprint of transport e.g. car sharing.

Table 3.2.4 presents a comparison of the ecological footprint per passenger-km for the different transport modes (based on UK data).

Table 3.2.4 The ecological footprint and ecological footprint index (100 = car) of different modes of transport in the UK

Transport mode	Specific ecological footprint [global m^2 per 1000 pkm]	Ecological footprint index [100 = car]
Aeroplane (short distance)	472	104
Aeroplane (long distance)	293	64
Walking	0.00	-
Bicycle	0.30	0.07
Car (Petrol)	455	100
Car (diesel)[23]	322	71
Motorcycles	436	96
Local Bus	334	73
Non-Local Bus / Coach	170	37
Train	174	38
Taxi (Petrol+diesel)	808	178

[22] WWF (2002) *Living Planet Report 2002*; WWF International, Gland, Switzerland

[23] Our calculations do not take into account recent scientific findings which suggest that soot particles from diesel exhaust fumes have a considerable global warming potential (see: Jacobson, Mark Z. (2002) Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming, *J. Geophys. Res.*, 107(D19), 4410, DOI:10.1029/2001JD001376 and http://www.agu.org/sci_soc/prrl/prrl0233.html)

Before considering the distance travelled by each of the different transport modes, it is clear that the use of petrol cars (including taxis[24]) and motorcycles, as well as short aeroplane trips, have a larger impact per km than travelling by bus, bicycle or train. This is due to the CO_2 emissions from direct fuel combustion, manufacture and maintenance of vehicles as well as to the low occupancy rates of individual travel modes. The impact of diesel cars is 71% of the impact of petrol cars[23]. Cycling has the lowest impact (apart from walking which has a zero footprint) and is only 0.3% of the impact of a car for every kilometre travelled. The conversion factor used to calculate the ecological footprint of car travel can change over time to reflect increases in the efficiency of cars and the amount of carbon dioxide emitted. Changes in vehicle occupancy and speed are other factors that change the algorithms.

b) Results of the Ecological Footprint of Passenger Transport in the South East

Table 3.2.5 presents the ecological footprint of all modes of passenger transport in the South East. Passenger transport in the South East creates an ecological footprint of 0.78 global hectares per capita. As the percentage split shows, car travel is responsible for 62% of the total environmental impact of all South East passenger transport followed by air travel with 32%. All other modes of transport together account for just 6% of the total footprint.

This very significant ecological impact of car use and air travel is due to both a high EF index (see table 3.2.4 above) and high passenger-kilometres, respectively. Although the specific impact of short distance flights is higher than those of long distance flights, the EF – and thus the ecological impact – of all air travel is mainly due to the long distances of international flights.

[24] The high impact of taxis is due to the fact that they travel some distance without passengers which leads to a low occupancy. It is assumed that one quarter of all taxi trips are done with the driver only, i.e. with no passenger, resulting in a passenger occupancy of 0.75.

Table 3.2.5 Ecological footprint of passenger transport in the South East

Mode of transport	Total pkm by all SE residents [billion (10^9) pkm]	Specific EF [global m^2 per 1000 pkm]	EF due to GHG emissions ['000 gha]	Built land EF ['000 gha]	Total EF ['000 gha]	Total EF per capita [gha/cap]	Percentage of total EF
Air travel - all services	62.0	1,237	2,044	0.140	2,044	0.252	32%
... total international	*60.1*	*293*	*1,436*	*0.07*	*1,436*	*0.177*	
... total domestic	*1.81*	*472*	*86*	*0.01*	*86*	*0.0106*	
*... intra EU-15 (1999)**	*11.1*	*472*	*521*	*0.06*	*521*	*0.0646*	
Walking (including short walks)	2.46	negligible	negligible	negligible	negligible	negligible	
Bicycle	0.60	0.30	0.00933	0.0086	0.0179	0.000002	0.0003%
Private hire bus	0.56	334	19	0.00072	18.8	0.0023	0.30%
Car	90.6	777	3,963	0.876	3,964	0.488	62%
... of which petrol cars	*78.7*	*455*	*3,583*	*0.762*	*3,584*	*0.442*	
... of which diesel cars	*11.8*	*322*	*380*	*0.114*	*380*	*0.0468*	
>>> car driver	*59.9*	*777*	*2,618*	*0.579*	*2,618*	*0.323*	
>>> ... of which petrol cars	*52.0*	*455*	*2,367*	*0.503*	*2,367*	*0.292*	
>>> ... of which diesel cars	*7.80*	*322*	*251*	*0.075*	*251*	*0.0309*	
>>> car passenger	*30.8*	*777*	*1,345*	*0.297*	*1,345*	*0.166*	
>>> ... of which petrol cars	*26.7*	*455*	*1,216*	*0.259*	*1,216*	*0.150*	
>>> ... of which diesel cars	*4.01*	*322*	*129*	*0.039*	*129*	*0.0159*	
Motorcycle/moped	0.16	436	6.86	0.00216	6.86	0.00085	0.11%
Van/lorry	1.13	777	48.4	0.0109	48.4	0.0060	0.76%
... of which petrol vans	*0.91*	*455*	*41.4*	*0.009*	*41.4*	*0.0051*	
... of which diesel vans	*0.22*	*322*	*7.03*	*0.002*	*7.03*	*0.00087*	
Other private (including invalid carriages, dormobiles, etc.)	0.14	455	6.24	0.0013	6.24	0.00077	0.10%
Local bus	1.82	334	60.8	0.0023	60.8	0.0075	0.96%
Non-local bus	0.96	170	16.4	0.00088	16.4	0.0020	0.26%
Surface Rail	6.69	174	116.1	0.0493	116.1	0.0143	1.83%
Taxi/minicab	0.81	808	65.6	0.0163	65.6	0.0081	1.03%
Other public transport (including air, ferries, light rail, etc.)	0.44	334	14.6	0.00056	14.6	0.0018	0.23%
Total	106.36	5,838	6,360	0.920	6,361	0.784	100 %

SE = South East; EF = ecological footprint; gha = global hectare; pkm = passenger-kilometre; cap = capita

3.2.4 Holidays

The resource consumption and impact caused by South East residents when on holiday have been included in the material flow analysis and ecological footprint of the South East. This not only includes the travel to the holiday location but consumption of resources and travel within the holiday location. Therefore, the impacts of energy use, food consumption and travel have all been taken into account.

South East residents spend more on holidays than any other region on a per capita basis. For 2000, South East residents spent over £4 billion collectively on holidays. This equates to nearly £500 per person. However there is a vast difference on expenditure between different groups in the South East. South East households earning over £739 a week spend nearly £2,000 a year on holidays while the lowest socio-economic group spend just over £200 a year. Table 3.2.6 highlights expenditure on holidays of different socio-economic groups and the number of holidays that they have per year.

Table 3.2.6 South East Residents Expenditure on Holidays in £

	Lowest 20 percent	Second Quintile Group	Third Quintile Group	Fourth Quintile Group	Highest 20 percent	Average
Average expenditure per person per year (£)	209	308	484	740	1,973	493
Average number of holidays per year	0.30	0.44	0.69	1.05	2.80	0.70

Individuals in the highest socio-economic group take the highest number of holidays averaging nearly three a year, whilst only one in three individuals have a holiday abroad in the lowest group.

Specific methodological approach for holidays

The methodological approach used for the transport, energy and food components of holidays is the same as described in the other relevant sections. A methodology was needed which embraced energy and food consumption by South East residents whilst on holiday and this is described below. The methodology draws heavily on information contained in one publication: that of van den Berg and Vringer entitled "The Energy Requirements of Holidays"[25].

Travel to destination

Four transport modes have been taken into account (air, car, sea and rail). Employing the same methodology as above, the total distances travelled for holiday purposes have been derived. For car and rail use, the National Travel Survey indicates the purpose of trip by mode. Therefore, car travel for the purpose of holidays represents 5% of the total passenger-km and for rail 1%. A slightly different approach was required for air and sea travel as such a breakdown was not available. Total expenditure on air travel for the UK in 2000 was approximately £20 million (ONS 2001[26]) of which £13 million was spent on holidays. Using this proxy for total passenger-km means that 66% of air travel is for the purpose of holidays. The same approach has been applied for sea travel giving a figure of 70%. The results are given below.

Table 3.2.7 Data and EF results for travel to holiday destinations

Mode	Percentage of total passenger-kilometres (%)	Total Passenger kilometres (millions km)	Fuel Consumption (tonnes)	Total GWP (tonnes)	Ecological Footprint (gha)
Air	70	40,706	1,444,307	4,604,361	1,191,184
Car	5	4387	169,482	771,745	199,699
Sea	66	304	8,743	39,292	10,166
Rail	1	68	8,201	4,565	1,181
Total		45,465	1,630,733	5,419,963	1,402,229

[25] van den Berg M, Vringer K (1999) The energy requirements of holidays. *NW&S Report no: 99112*, Department of Science, Technology and Society (STS), Utrecht University

[26] Office of National Statistics (2001) *Travel Trends – A Report on the 2000 International Passenger Survey*, London: The Stationery Office.

Approximately 85% of the total ecological footprint for holidays is composed of air travel proving to be the most popular form of travel with the highest impact. Other transport modes have been excluded from the analysis (bus for example). However, it is perceived that the impact of other transport modes will be minimal compared to that of aviation and car travel.

Energy consumption

Van den Berg and Vringer calculate that the energy requirement of a hotel is 136 MJ per person per day. The average person in the South East spends 7.1 days on holiday a year. Therefore, the South East residents are responsible for 56.85 million holiday days. This is assuming the South East has a population of 8.1 million residents. It is assumed that the energy consumed was 40% electricity and 60% gas; this representing the average European breakdown on energy consumption.

Table 3.2.8 Data and EF results for energy use in holidays

	Energy Use per Holiday Day (MJ)	Total Holiday (days)	Total Energy Requirement (GJ)	Energy Breakdown (GWh)	Total CO_2 (tonnes)	EF per GWh (gha)	Total EF (gha)
Electricity				**859**	**378,023**	**114**	**97,798**
Gas				**1,289**	**244,856**	**49**	**63,346**
Total	**136**	**56,850,556**	**7,731,676**	**2,148**	**622,879**		**161,144**

Food

The average South East resident consumes 1.7 kg of food per day while in the UK[27]. It is assumed that the same amount of food will be consumed on a daily basis while the South East resident is on holiday. Chapter 3.4 established the material flow analysis and ecological footprint of food consumption in which figures for the impact of food were derived. These figures have also been applied in this section.

On holiday, South East residents consume nearly 97 thousand tonnes of food. The average ecological footprint per tonne of food has been calculated as 2.71 ha/tonne giving a total ecological footprint of 262 thousand hectares. This figure is likely to be an under-estimate as individuals are likely to purchase more food and drink items while on holiday. However, it does provide an estimate of the impact of food.

Holiday travel

The transport from the airport to the holiday address is assumed to be made by a regional bus/coach, for which a distance of 50 km is travelled (van den Berg and Vringer 1999). In addition to this, it is assumed that the holidaymaker travels an average of 25 km per day by car. Applying the same conversion factors used in the transport section above gives an ecological footprint of 46,212 hectares for car travel and 13,249 hectares for bus travel.

[27] This figure is based on the National Food Survey

Total impact of holidays

Table 3.2.9 provides a summary of the results for holidays.

Table 3.2.9 Global Warming Potential and Ecological Footprint of South East Residents' Holidays

Component	GWP (tonnes)	Ecological Footprint (ha)
Travel to Destination	5,419,963	1,402,229
Food	120,485	261,924
Energy	622,879	161,144
Holiday Travel	176,545	59,461
Total	6,339,873	1,884,758

By far the most significant component is travelling to the destination (mostly aviation). 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% by 2015. Taking into account the predicted growth in car travel, air travel will contribute to over 38% 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%. By 2025, air travel will contribute more to the ecological footprint and carbon dioxide emissions than other forms of transport.

3.3 Freight Transport

3.3.1 Freight distribution within the UK

Freight is distributed within the UK by road, rail, costal shipping and pipeline. In 1999, 81% of all goods lifted (measured in tonnes) were distributed by road, 8% by pipeline, 7% by water and the remaining 4% by rail (Figure 3.2)[28]. Road transport was responsible for 64% of all goods moved (measured in tonne-kilometres) in that year (Figure 3.3).

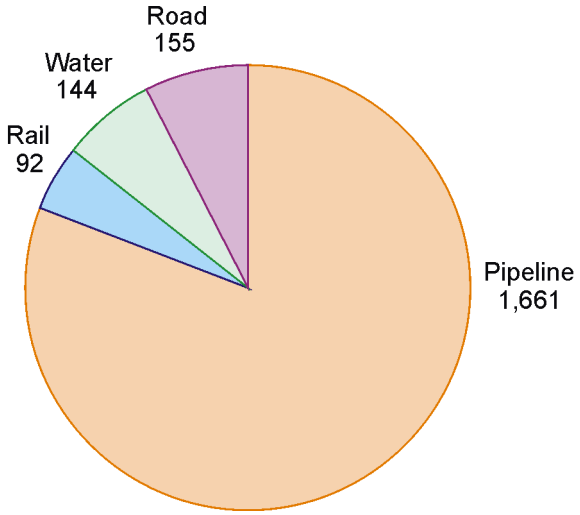

Figure 3.2 UK freight distribution by mode: goods lifted in 1999 (million tonnes)[28]

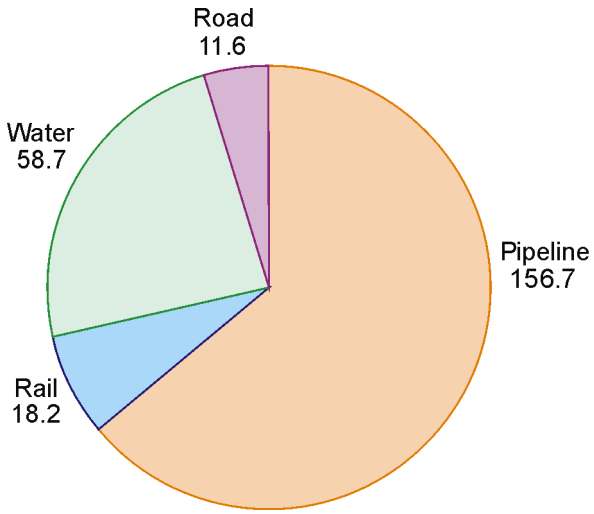

Figure 3.3 UK freight distribution by mode: goods moved in 1999 (billion (10^9) tonne-kilometres)[28]

Since 1953, the distribution of products by water and pipeline has increased in the UK, whereas rail freight has almost halved. The most significant change has been a large expansion in road freight distribution, which has increased five-fold (Figure 3.4).

[28] UK Department for Transport (2002) "Domestic freight transport: by mode: 1991-2001"; a complete modal breakdown for freight transport for 2000 and 2001 was not available.

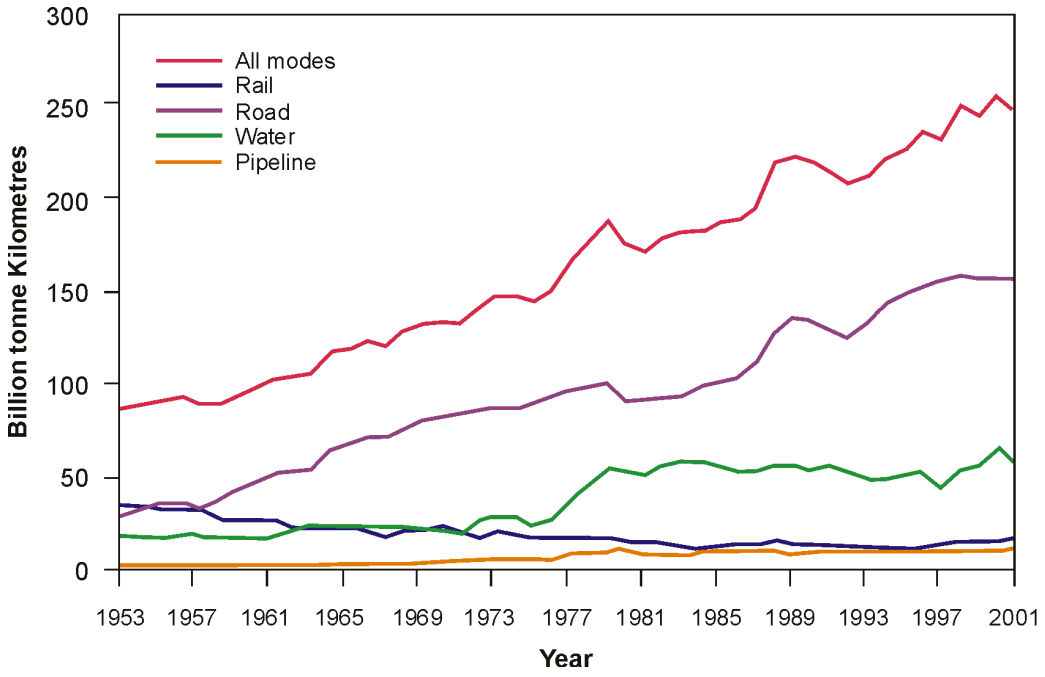

Figure 3.4 Long term trends in UK freight distribution: goods moved, by mode (billion = 10^9)[29]

A proportion of the goods distributed within the UK are destined for consumption in the South East region. In this section the method used to determine this fraction of UK freight transport, the associated mass flow and its Ecological Footprint is described.

Method

The first step is to determine the amount of goods lifted (tonnes) and moved (tonne-kilometres) in the UK as a whole, based on a modal breakdown for road, rail, water and pipeline[30]. Data for 1999 are used, as a modal breakdown for 2000 was not available[31]. The options for a proxy for the ratio of total UK freight to that destined for consumption in the South East are as follows:

1) On a per capita basis – the fraction of the UK population residing in the South East;
2) Based on the amount of goods entering the South East region[32]
3) On the basis of the fraction of total UK household consumption for which the South East is responsible.

It was decided that 2) is the most appropriate method, as it is based on actual freight movements to the South East region. In 2000, 11.8% of all UK freight movements are to the South East. This percentage is therefore used to determine the fraction of UK freight for which the South East is responsible.

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[29] Department for Transport (2003) Focus on Freight; page 3, chart 2.2. DfT, TSO, London http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/downloadable/dft_transstats_022097.pdf

[30] All goods vehicles, including those under 3.5 tonnes gross vehicle weight are included. Articulated lorries account for 853 billion tonne-kilometres and total UK road freight amounts to 1,593 billion tonne-kilometres. It was assumed that 90.25% of all UK freight is associated with products that are consumed in the UK as 200 million tonnes of the 2,052 million tonnes of goods lifted in the UK is exported.

[31] UK Department for Transport (2002) "Transport statistics for the UK"

[32] UK Department for Transport (2002) "Goods lifted by origin and destination Government Office Region (2000)" In 'Transport of Goods by Road in Great Britain: 2001'. Based on this data, 11.8% of all UK freight movements are to the SE.

(Table 3.3.1). In total, the distribution of products to the South East involves 28.9 billion (10^9) tonne-kilometres.

Table 3.3.1 Freight transport to the South East

Mode	Goods moved (billion (10^9) tonne-kilometres)	Fraction
Road (total)	**18.5**	**64 %**
Road (artic)	***9.9***	
Road (truck)	***8.6***	
Rail (total)	**2.1**	**7 %**
Water	**6.9**	**24 %**
Pipeline	**1.4**	**5 %**
All modes	**28.9**	**100 %**

Table 3.3.2 describes the greenhouse gas (GHG) emissions associated with these freight movements. Specific emission factors for the transport modes have been derived from the UK National Atmospheric Emissions Inventory (NAEI), UK Emission Factors Database[33].

In total, freight distribution to the South East is responsible for 14.3 million tonnes of CO_2 equivalents. Road freight accounts for a disproportionately large fraction of these emissions, at 97.4%, as lorries produce far more CO_2 than other modes, particularly shipping.

Table 3.3.2 GHG emissions associated with freight transport in the South East

Mode	Goods moved		Total GHG Emissions	
	(billion (10^9) tonne-kilometres)	Fraction	('000 tonnes CO_2 eq.)	Fraction
Road (total)	**18.5**	**64%**	**13,948**	**97.4%**
Road (artic)	***9.9***		***1,664***	
Road (truck)	***8.6***		***12,284***	
Rail (total)	**2.1**	**7%**	**64.4**	**0.5%**
Rail (diesel)			***17.3***	
Rail (electric)			***47.1***	
Water	**6.9**	**24%**	**277**	**2.0%**
Pipeline	**1.4**	**5%**	**13.7**	**0.1%**
All modes	**28.9**		**14,303**	

The Ecological Footprint of UK freight distribution

The Ecological Footprint of freight transport is shown in Table 3.3.3. This amounts to 3.7 million global hectares or 0.46 hectares per South East resident.

[33] http://www.naei.org.uk/emissions/index.php

Table 3.3.3 The EF of freight transport in the South East

Mode	Goods moved (billion (10^9) tonne kilometres)	Total EF ('000 gha)	EF per capita (gha/cap)
Road (total)	**18.5**	**3,621**	**0.446**
Road (artic)	***9.9***	***432***	***0.053***
Road (truck)	***8.6***	***3,189***	***0.393***
Rail (total)	**2.1**	**16.7**	**0.002**
Rail (diesel)		***4.49***	***0.001***
Rail (electric)		***12.2***	***0.002***
Water	**6.9**	**71.9**	**0.009**
Pipeline	**1.4**	**3.55**	**0.0008**
All modes	28.9	3,713	0.458

Material Flow Analysis of UK freight distribution

The material inputs for freight transport fuels are associated with the energy carriers and the hidden flows. 4.5 million tonnes of fuel are consumed directly and 60,100 tonnes of hidden flows are generated. This equates to a total of 0.57 tonnes per person in the South East (Table 3.3.4).

Table 3.3.4 provides a summary of material inputs and outputs.

Table 3.3.4 Material flows associated with freight transport in the South East

Mode	Goods moved (billion (10^9) tonne-kilometres)	Energy Carriers (tonnes)	Energy Carriers (EC) ('000 t)	Hidden Flows of EC ('000 t)	Total MFA per capita (tonnes/cap)
Road (total)	**18.5**	**Diesel**	**4,405**	**46.6**	**0.543**
Rail (total)	**2.1**	**Electricity/Diesel**	**25.5**		**0.009**
Rail (diesel)		***diesel***	***5.6***		***0.001***
Rail (electric)		***electricity***	***19.9***		***0.008***
Water	**6.9**	**Fuel Oil**	**88.2**	**13.5**	**0.011**
Pipeline	**1.4**	**Electricity**	**5.8**		**0.002**
All modes	**38.9**		**4,524**	**60.1**	**0.565**

3.3.2 Imports

In 2000, the UK imported 210 million tonnes of goods and exported 197 million tonnes of products. In this study it is imports that are assessed, as it is UK consumption that is being considered. These items were sourced in virtually every country, however, 61% of all imports arrive from Europe. A proportion of imported goods will have been destined for consumption in the South East region. In

this section the method used to determine the fraction of UK imports supplied to the South East, and the associated mass flow and Ecological Footprint is described.

Method

The first stage in this process is to model international freight transport flows associated with UK imports in order to provide information on fuel consumption and greenhouse gas emissions. There are several variables that need to be considered when looking at the transport related environmental impacts of imported products. Goods are imported into the UK by lorry, rail, ship and plane and the distance will vary for each mode of transport and the country of origin. Data on the volume of goods being moved, the distance travelled and the mode of transport are required. This information is obtained from government trade and transport statistics including a HM Customs and Excise trade database[34].

The data generated by HM Customs and Excise on UK imports includes:

- the quantity imported (in tonnes, kilograms or pounds sterling) based on SIC and Com Code classification; and
- the country or continent of origin.

A significant proportion of UK imports are from EU member states (38%). Other major exporting regions are Western European countries (other than EU) and Asia and Oceania (Table 3.3.6).

Table 3.3.6 UK imports by origin

	UK Imports	
	Tonnes	Percent
European Union	80,059,597	38%
W Europe ex EC	35,089,432	17%
Asia & Oceania	23,706,096	11%
North America	17,616,686	8%
Other America	16,241,658	8%
Eastern Europe	13,973,468	7%
Middle East and North Africa	13,000,282	6%
Sub Saharan Africa	10,809,346	5%
Total	210,496,566	

The three top countries that export products to the UK are Norway, Germany and Australia. A significant fraction of UK imports (16 per cent) are from Norway and crude oil accounts for 88% (or 29.5 million tonnes) of the 33.5 million tonnes of goods exported by Norway to the UK.

Mineral fuels, such as coal and crude oil make up almost 40% of all UK imports. Other imports of significance in terms of quantity (tonnes) include metal ores, paper, iron and steel and wood and wood products (Table 3.3.7). The 21 product groups, of 99 in total, listed in Table 3.3.7 amount to 85 per cent of UK imports.

[34] This is available online at http://www.uktradeinfo.co.uk

Table 3.3.7 UK imports by product type, 2000

Product	Million tonnes
Mineral fuels (coal and oil)	83.0
Metal ores	18.4
Paper and paperboard	8.3
Iron and steel	7.4
Wood and articles of wood	7.4
Salt; sulphur; earths and stone; lime and cement	6.1
Plastics and plastic products	5.9
Vehicles	4.7
Prepared animal fodder and residues and waste from the food industries	4.6
Organic chemicals	4.5
Inorganic chemicals	3.7
Fertilizers	3.5
Nuclear reactors and parts thereof	3.4
Cereals	3.1
Edible fruits and nuts	3.0
Beverages, spirits and vinegar	2.5
Sugars and sugar confectionery	2.3
Electrical machinery and equipment	2.2
Vegetables	2.2
Articles of iron or steel	2.1
Pulp of wood and waste paper	2.1
Total of above	180.3

The analysis of imports includes the movement of food products from origin to the point of departure (within the country exporting the product to the UK) as well as transportation from point of departure to point of entry in the UK.

Distance tables were used in the instances where information on the distance of a transport stage was unavailable. Information on the mode of transport was obtained from government statistics. The average distance that goods move to the point of departure is 500 kilometres and the distance from the point of departure to the UK is 5,300 kilometres. However, the distances from each region of origin to the UK depend on the mode of transport. Distances between two points can vary significantly, particularly in the case of transportation of freight by sea and plane. For example, the average distance between the Asia and Pacific region and the UK by sea is almost twice that by plane.

The data generated during this assessment procedure are in the form of tonne-kilometres as the reference data for the environmental impacts of food distribution are provided on a per tonne-kilometre basis[35]. Therefore, the reference data was used to determine the greenhouse gas emissions of each transport stage. These are measured in terms of tonnes of carbon dioxide equivalent.

Consumption levels in the South East were used to determine the fraction of UK imports that are destined for consumption in the South East. The data source for this is the Household Expenditure Survey[36]. Although 13.6 per cent of the UK population live in the South East, households in this region account for 15.9 per cent of UK consumption. The latter figure is therefore used as a proxy, so

[35] The DEFRA guidelines for Environmental Reporting provide data on greenhouse gas emissions for freight transport on this basis (http://www.defra.gov.uk/environment/envrp/gas/10.htm) as does the IPCC.
[36] ONS (2002) Family spending 2001-02.

that of the 1.12 trillion (10^{12}) tonne-kilometres associated with UK imports, 178 billion (10^{9}) tonne-kilometres is allocated to the South East (Table 3.3.8).

Table 3.3.8 Goods moved and transport GHG emissions associated with imports destined for the South East

Mode	Unit (billion (10^9) tonne-kilometres)	Fraction	GHG Emissions as CO_2 equivalent [tonnes] Total GWP Emissions	Fraction
Road	**16.9459**	**9.52%**	**2,953,670**	**60.7%**
Ship	**159.5022**	**89.59%**	**1,250,497**	**25.7%**
Ferry	**0.4733**	**0.27%**	**9,863**	**0.2%**
Rail	**0.0795**	**0.04%**	**2,484**	**0.1%**
Air	**1.0373**	**0.58%**	**647,077**	**13.3%**
All modes	**178.038**		**4,863,592**	

In terms of goods moved, expressed as tonne-kilometres, shipping accounts for 90% of all trade related transport and road freight a large proportion of the remainder (Table 3.3.8). However, each mode of transport produces differing quantities of carbon dioxide emissions. Table 3.3.9 shows that a lorry produces 17 times more CO_2 than intercontinental shipping and long-haul airfreight releases 57 times more CO_2 than shipping. This is the reason for the large differences in modal share of goods moved and GHG emissions in Table 3.3.8.

Table 3.3.9 Carbon dioxide emissions for alternative freight transport modes

	CO_2 Emissions		
	per tonne	per kilogram	relative to shipping
Intercontinental ship	0.00001	0.01	1
Rail	0.00003	0.03	3
Ferry	0.00004	0.04	4
Lorry	0.00017	0.17	17
Airfreight (long haul)	0.00057	0.57	57
Airfreight (short haul)	0.00158	1.58	158

The Ecological Footprint of Imports

The Ecological Footprint calculation for imported goods is provided in the table below. The Footprint amounts to 1.26 million global hectares, which is equivalent to 0.156gha per person.

Table 3.3.10 The Ecological Footprint of Direct Energy Consumption

Mode	Unit (billion (10^9) tonne-kilometres)	Total GHG Emissions (tonnes CO_2 eq.)	Ecological Footprint [gha] Total EF	Total EF per capita
Road	16.9	2,953,670	766,818	0.094
Ship	159.5	1,250,497	324,648	0.040
Ferry	0.5	9,863	2,561	0.000
Rail	0.1	2,484	645	0.000
Air	1.0	**647,077**	167,991	0.021
All modes	178.0	4,863,592	1,262,663	0.156

Material Flow Analysis for Imports

The principal material input associated with imported goods is transport fuel. Table 3.3.11 describes the inputs in the form of energy carriers and hidden flows for each fuel. In total 1.46 million tonnes of fuel (and 4,100 tonnes of hidden flows) are required to import the goods destined for the South East. This is equivalent to 0.18 tonnes per capita.

Table 3.3.11 Material flows associated with transport fuels

		MFA [tonnes]			
Mode	**Fuel**	**Energy Carriers**	**Hidden Flows of energy carriers**	**Total MFA**	**Total MFA per capita**
Road	**Diesel**	**899,025**	**-**	**899,025**	**0.111**
Ship	**Fuel Oil**	**369,605**	**-**	**369,605**	**0.046**
Ferry	**Fuel Oil**	**3,134**	**-**	**3,134**	**0.000**
Rail	**Electricity**	**1,733**	**4,100**	**5,833**	**0.001**
Air	**Kerosene**	**183,733**	**-**	**183,733**	**0.023**
All modes		**1,457,229**	**4,100**	**1,461,329**	**0.180**

Imports of goods also accounts for 4.58 million tonnes of carbon dioxide and 13.5 thousand tonnes of methane emissions (Table 3.3.12).

Table 3.3.12 Mass balance data for imports to the South East[37]

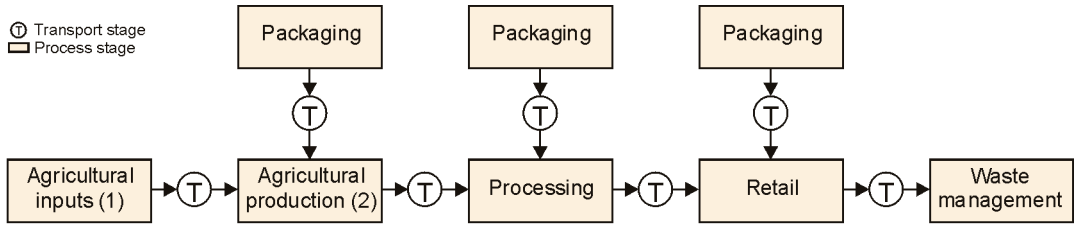
Inputs (tonnes)		**Output (tonnes)**	
Energy carriers	**1,457,229**	**Carbon dioxide**	**4,578,788**
		Methane	**13,562**
Hidden flows	**4,100**	**Hidden flows**	**4,100**
Total	**1,461,329**		**4,596,450**

[37] Oxygen has not been taken into account on the input side

3.4 Food

3.4.1 Introduction

The UK 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. 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 3.5 provides a simplified version of the food supply chain; in practice there will be considerably more processes and transport stages.



1. Agricultural inputs include machinery, pesticides, Feed, fertiliser, seed and packaging
2. There are many variables associated with agricultural production, including: whether crops or livestock are produced, the degree of specialisation, field and holding size, machinery use, dependency on external inputs.

Figure 3.5 A basic representation of a food supply chain

During each stage, energy and resources are consumed which results in solid waste and liquid and gaseous emissions. The environmental impacts associated with the food system are, therefore, diverse and include:

- water pollution;
- habitat loss;
- soil erosion as a result of agricultural production;
- greenhouse gas and air pollutant emissions from energy used for food packaging, processing and distribution; and
- solid waste in the form of food and packaging during each stage in the supply chain.

The energy consumed in supplying food (described as embodied energy) is a useful indicator of the environmental impact of food supply, as many environmental problems, such as climate change, acidification and depletion of non-renewable resources, are related to energy consumption. As the food system has become more complicated and supply chains more geographically dispersed, the environmental impacts 'post farm gate' have become more significant. Studies have found that the

consumption of food accounts for 20-35% of the total energy use of a household (Noorman and Uiterkamp 1998)[38].

The total Ecological Footprint for food consumption includes both the notional 'energy land' area required (to sequester the carbon from the CO_2 emissions associated with the embodied energy of food products) as well as the pasture or crop land area to produce the food.

In the analysis of food supply in the South East the food system is separated into the following components:

- food production (up to the farm gate);
- food packaging;
- freight transport (within the UK and the international transport related to UK food imports); and
- food and packaging waste management.

3.4.2 Food consumption in the South East

Information on food supplied to the South East region was obtained from the National Food Survey[39]. This document provides a breakdown for food consumed within and outside the home for each Government Office Region. The data are presented in terms of grams per person per week, which is converted to total annual consumption (tonnes) in the South East region (Table 3.4.1).

Table 3.4.1 Food consumption in the South East

	Total (tonnes)	Animal based	Plant based	Water based
Summary				
Household	**4,347,483**	**1,515,575**	**2,195,984**	**635,924**
Restaurants and Commercial	**502,156**	**78,066**	**151,069**	**273,021**
Total	4,849,639	1,593,641	2,347,053	908,945
Household				
Wholemilk	**239,263**	**239,263**		
Skimmed milk	**498,358**	**498,358**		
Yoghurt and fromage frais	**63,297**	**63,297**		
Other milks and dairy products	**48,106**	**48,106**		
Cream	**9,706**	**9,706**		
Cheese (natural & processed)	**51,904**	**51,904**		
Beef and veal	**43,886**	**43,886**		
Mutton and lamb	**27,007**	**27,007**		
Pork/ham/bacon	**75,112**	**75,112**		
Poultry (uncooked)	**93,258**	**93,258**		
Poultry (cooked)	**13,925**	**13,925**		
All other meats	**140,519**	**140,519**		
Total fish	**63,297**	**63,297**		
Eggs	**49,194**	**49,194**		
Butter	**19,833**	**19,833**		
Margarine	**9,706**		**9,706**	
Low-fat and dairy spreads	**27,851**	**27,851**		
Vegetable and salad oils	**19,833**		**19,833**	
Other fats (animal)	**4,220**	**4,220**		
Sugar	**48,106**		**48,106**	

[38] Noorman KJ, Uiterkamp TS (1998) *Green Households? Domestic Consumers, Environment and Sustainability*. Earthscan, London

[39] Office for National Statistics (2001) National Food Survey, 2000

	Total (tonnes)	Animal based	Plant based	Water based
Honey, preserves, syrup & treacle	**17,723**		**17,723**	
Fresh potatoes	**285,680**		**285,680**	
Fresh green vegetables	**111,825**		**111,825**	
Other fresh vegetables	**225,759**		**225,759**	
Processed vegetables	**230,823**		**230,823**	
Fresh fruit	**346,446**		**346,446**	
Other fruit (e.g. tinned)	**34,602**		**34,602**	
Fruit juices	**153,601**		**153,601**	
Bread	**302,138**		**302,138**	
Flour	**18,145**		**18,145**	
Cakes	**59,921**		**59,921**	
Biscuits	**57,811**		**57,811**	
All other cereals	**188,625**		**188,625**	
Tea	**13,503**		**13,503**	
Coffee	**7,174**		**7,174**	
Cocoa/drinking chocolate	**2,110**		**2,110**	
Branded food drinks (e.g. Horlicks)	**2,110**		**2,110**	
Soups,	**34,180**		**34,180**	
Mineral water	**74,690**			**74,690**
Ice-cream & other frozen dairy	**46,840**	**46,840**		
Soft drinks (concentrated)	**49,372**			**49,372**
Soft drinks (ready to drink)	**177,654**			**177,654**
Soft drinks (low cal, concentrated)	**16,879**			**16,879**
Soft drinks (low cal, ready to drink)	**118,154**			**118,154**
Beer and lager	**91,570**			**91,570**
Wine	**80,176**			**80,176**
Spirits (e.g. whisky)	**27,429**			**27,429**
Chocolate confectionery	**19,411**		**19,411**	
Non-choc confectionery	**6,752**		**6,752**	
Sub Total	4,347,483	1,515,575	2,195,984	635,924
Restaurants and Commercial				
Yoghurt and fromage frais	**2,532**	**2,532**		
Meat and Meat Products	**44,730**	**44,730**		
Total fish	**9,706**	**9,706**		
Fresh potatoes	**45,996**		**45,996**	
Fresh green vegetables	**9,706**		**9,706**	
Other fresh vegetables	**32,492**		**32,492**	
Fresh fruit	**9,706**		**9,706**	
Bread	**37,556**		**37,556**	
Biscuits	**4,642**		**4,642**	
Soups,	**5,064**		**5,064**	
Ice-cream & other frozen dairy	**21,099**	**21,099**		
Soft drinks (ready to drink)	**127,860**			**127,860**
Beer and lager	**145,161**			**145,161**
Chocolate confectionery	**5,908**		**5,908**	
Sub Total	502,156	78,066	151,069	273,021

3.4.3 The GHG emissions associated with food production and processing

Energy is used during each stage in the life cycle of a food item from the extraction of raw materials, processing, packaging and transporting the final product to the wholesaler or retailer, through to waste processing and final disposal. The Energy Analysis Program (EAP)[40] software package was used to determine the energy required, and the associated greenhouse gas emissions, for each of the food and drink products listed in Table 3.4.1. The GHG emissions (in tonnes CO_2 equivalent per tonne)

[40] EAP (Energy Analysis Program), Version 3.2 (November 2000), Center for Energy and Environmental Studies, University of Groningen, The Netherlands

associated with food and drink distribution, the manufacture and waste management of food packaging and the waste management of food are calculated separately (see below).

EAP software was employed to calculate the energy required for the following:

- *Residual goods* (raw materials whose precise nature or size is unknown including products and services indirectly used in production such as office requisites and maintenance of the premises);
- *Capital goods* (goods such as buildings and machinery required for production); and
- Intermediate *trades and services* (wholesale, retail trade etc.).

The EAP program is used to calculate, for each food and drink category, the GHG emissions associated with the production and processing of these products. This is expressed as the combined global warming potential (GWP) in kg CO_2 equivalents per tonne of the food product (Table 3.4.2).

Table 3.4.2 Price, purchase tax and global warming potential (GWP) of the greenhouse gases emissions for the 48 food and drink groups.

Product	Approximate price [1] (£/kg or £/litre)	Value Added Tax or excise duty rate (%)	GWP of GHG emissions calculated by EAP (t CO_2 equivalent / t)
Wholemilk	0.90	0	3.52
Skimmed milk	0.90	0	3.77
Yoghurt and fromage frais	2.70	0	7.21
Other milks and dairy products	2.70	0	7.21
Cream	2.00	0	12.17
Cheese (natural & processed)	5.15	0	13.86
Beef and veal	4.00	0	19.30
Mutton and lamb	5.00	0	13.09
Pork/ham/bacon	5.43	0	13.89
Poultry (uncooked)	2.60	0	10.63
Poultry (cooked)	12.00	0	26.76
All other meats	7.00	0	17.17
Total fish	5.58	0	17.23
Eggs	2.07	0	5.48
Butter	2.90	0	17.36
Margarine	0.80	0	3.02
Low-fat and dairy spreads	1.70	0	4.41
Vegetable and salad oils	0.80	0	3.00
Other fats (animal)	3.30	0	5.59
Sugar	0.50	0	1.67
Honey, preserves, syrup & treacle	2.00	0	4.01
Fresh potatoes	0.35	0	1.88
Fresh green vegetables	0.70	0	1.67
Other fresh vegetables	0.60	0	2.33
Processed vegetables	1.02	0	3.72
Fresh fruit	1.30	0	3.40
Other fruit (e.g. tinned)	1.50	0	3.32
Fruit juices	0.60	0	2.43
Bread	0.78	0	1.49
Flour	0.30	0	1.15
Cakes	3.00	0	5.93
Biscuits	1.20	0	2.72
All other cereals	1.30	0	4.07
Tea	5.70	0	6.01
Coffee	15.70	0	13.62

Product	Approximate price [1] (£/kg or £/litre)	Value Added Tax or excise duty rate (%)	GWP of GHG emissions calculated by EAP (t CO_2 equivalent / t)
Cocoa/drinking chocolate	**6.60**	**0**	**7.31**
Branded food drinks (e.g. Horlicks)	**6.30**	**0**	**8.81**
Soups,	**5.40**	**0**	**10.71**
Mineral water	**0.40**	**0**	**0.83**
Ice-cream & other frozen dairy	**2.00**	**17.5**	**7.26**
Soft drinks (concentrated)	**0.70**	**17.5**	**0.92**
Soft drinks (ready to drink)	**1.40**	**17.5**	**0.93**
Soft drinks (low cal, concentrated)	**1.40**	**17.5**	**1.01**
Soft drinks (low cal, ready to drink)	**1.40**	**17.5**	**1.15**
Beer and lager	**2.60**	**35.5**	**1.91**
Wine	**7.30**	**38.5**	**14.33**
Spirits (e.g. whisky)	**17.80**	**61.5**	**23.22**
Chocolate confectionery	**3.40**	**17.5**	**6.58**
Non-choc confectionery	**4.00**	**17.5**	**4.64**

[1] from 'Sainsbury's online shopping' as of October 2001

The data on food consumption and GHG emissions per tonne of food product, provided in Tables 3.4.1 and 3.4.2, are then combined to determine the total greenhouse gas emissions associated with the production and processing of the food supplied to consumers in the South East (Table 3.4.3). Approximately one per cent of the food consumed in the region is produced organically. The GHG emissions associated with the 4.8 million tonnes of food consumed in the South East amount to 23 million tonnes of CO_2 equivalent. However, 1 million tonnes of food produced is not consumed and becomes waste. This wastage occurs throughout the food supply chain: at catering establishments, in the home, at the food retail outlet and during distribution. Approximately 4.7 million tonnes of carbon dioxide emissions are associated with the production of food that is not consumed.

Table 3.4.3 GHG emissions associated with food production for consumption in the South East

	Food supplied (tonnes)	GHG Emissions (tonnes CO_2 eq.)		
		Organic	Conventional	Total
Household	**4,347,483**	**135,219**	**21,155,445**	**21,290,664**
Restaurants and Commercial	**502,156**	**10,665**	**1,668,511**	**1,679,176**
Food Waste	**1,081,753**	**29,836**	**4,667,950**	**4,697,786**
Total	5,931,392	175,719	27,491,907	27,667,626

The GHG emissions resulting from food packaging

Food is packaged in paper, glass, metal and plastic containers. Table 3.4.4 provides a summary of the quantity of packaging associated with the food supplied to consumers in the South East and the GHG emissions resulting from the production of this packaging.

Table 3.4.4 Food Packaging

	Tonnage	Embodied Energy (GJ)	CO_2 Emissions (tonnes)
Paper	**71,563**	**2,576,259**	**193,305**
Glass	**272,722**	**4,416,729**	**331,402**
Aluminium	**28,195**	**5,063,870**	**379,959**
Steel	**117,264**	**3,534,005**	**265,168**
Plastic	**169,389**	**11,412,272**	**856,301**
Packaging Total	659,132	27,003,135	2,026,135

The production of the 659 thousand tonnes of materials used to package the food supplied to the South East results in 2 million tonnes of carbon dioxide emissions.

The GHG emissions associated with food distribution

Food distribution involves the international transport associated with food imports and freight transport within the UK. Table 3.4.5 provides a summary of the carbon dioxide emissions resulting from food transportation. On average 30 per cent of the food products consumed in the South East are imported. Food imports are normally transported from origin to point of departure by lorry, with the average distance being 507 kilometres. From this point the products are moved to the UK by ship or plane and are distributed to the South East by road. Trade related transportation of foodstuffs and food distribution within the UK results in 264 thousand tonnes and 470 thousand tonnes of carbon dioxide emissions, respectively.

Table 3.4.5 Food distribution

	Food Supply (tonnes year)	Fraction imported	Quantity imported	CO_2 emissions (tonnes)		
				Transport from origin to the UK	UK food distribution	TOTAL
Household food consumption	**4,347,483**	**0.317**	**1,366,620**	**204,204**	**344,214**	**548,419**
Food consumption outside the home	**502,156**	**0.155**	**77,774**	**11,649**	**40,148**	**51,797**
Food wastage	**1,081,753**	**0.298**	**322,184**	**48,148**	**85,735**	**127,579**
Total	5,931,392	0.298	1,766,578	264,001	470,098	727,794

The GHG emissions associated with food wastage

The majority of food that is not consumed is sent to landfill, where anaerobic decomposition results in methane emissions. Methane is a stronger greenhouse gas than CO_2 with a global warming potential 21 times that of carbon dioxide. The 1 million tonnes of food waste generated produces 472 thousand tonnes of GHGs, expressed as carbon dioxide equivalents (Table 3.4.6).

Table 3.4.6 The GHG emissions associated with waste food

	Food supplied (tonnes)	Food waste (tonnes)	Landfill CH_4 Output (tonnes CO_2 eq.)
Household	**4,347,483**	**695,597**	**303,691**
Restaurants and Commercial	**502,156**	**386,156**	**168,592**
Total	4,849,639	1,081,753	472,283

Total GHG emissions associated with food supply in the South East

The total GHG emissions associated with food supply in the South East are presented in Table 3.4.7. In the South East in 2000, food supply was responsible for 30.9 million tonnes of CO_2 equivalents, which is equivalent to 3.8 tonnes of carbon dioxide per person. Each tonne of food supplied to the South East resulted in 6.3 tonnes of GHG emissions (CO_2 eq.).

Table 3.4.7 Summary of GHG emissions related to food supply

		GHG emissions (tonnes CO_2 eq.)				
	Input (tonnes)	Food packaging	Food production	UK food distribution	Landfilled food waste	Total
Household	**4,347,483**		**21,290,664**	**548,419**	**303,691**	**22,142,773**
Restaurants and Commercial	**502,156**		**1,679,176**	**51,797**	**168,592**	**1,899,565**
Food packaging	**659,132**	**2,026,135**				**2,026,135**
Food waste	**1,081,753**		**4,697,786**	**127,579**		**4,825,365**
Total	6,590,525	2,026,135	27,667,626	727,794	472,283	30,893,838

The "food production" figure of 227.7 Mt CO_2 includes 8.8 Mt of CO_2 which come from the imports of food products from outside the UK. This is 32% of the total food CO_2 emissions. The inclusion of GHG emissions resulting from the production and international transportation of imported foodstuffs is in contrast to official national CO_2 statistics as GHG accounting by ONS follows the "producer responsibility" or "territorial" principle, i.e. only the CO_2 emissions occurring on UK territory are accounted for.

3.4.4 Calculating the Ecological Footprint of food and drink supply

For each food and drink item, an EF is determined and is measured in terms of hectares per tonne of product[41]. The product EF for each food and drink category consists of two main components:

- *Energy land:* the area of land (ha) required to absorb the GHG emissions (as CO_2 equivalents); and
- *Grazing and arable land:* the total area required (ha) to produce one tonne of the food or drink product.

The area of 'energy land' was calculated by assuming that 5.2 hectares of newly planted forest in the UK can sequester one tonne of CO_2 per annum. This energy land area is then converted into the

[41] Detailed examples of EF calculations for various food products are provided in the technical report - *"Material Flow Analysis and Ecological Footprint of York"* which is available at www.yorkfootprint.org.

equivalent number of hectares of land of global average productivity assuming an average UK forest productivity of 1.345 times the global average.

The area of grazing and/or crop land required to produce a tonne of the food or drink was estimated using 'yield factors' for the main food categories, expressed as kilograms per hectare (Table 3.4.8). Yield factors for 'composite' foods (e.g. ice cream, biscuits) were calculated assuming the same proportions for their constituent raw-material ingredients as were used for the EAP analysis.

Table 3.4.8 Yield factors for food products

Food or drink category	Yield factor (kg/ha)
cheese	**3**
butter	**3**
beef, buffalo meat	**24**
marine fish and seafood	**29**
sheep, goat meat	**52**
non-bovine, non-goat, non-mutton, non-buffalo	**107**
ice-cream (pasture land milk)	**168**
margarine	**240**
olive oil	**262**
milk	**336**
cocoa	**408**
coffee & tea	**696**
ice-cream (fat/oil crop land)	**1,073**
eggs	**1,101**
sunflower oil	**1,288**
fruit juice	**2,424**
cake and biscuits (crop land veg oil)	**2,575**
cereals	**2,641**
sugar	**3,229**
bread	**5,283**
cake and biscuits (crop land cereals)	**5,283**
ice-cream (sugar crop land)	**8,072**
cake and biscuits (crop land sugar)	**9,687**
veg & fruit	**12,120**
roots and tubers	**13,385**
soups (meat pasture land)	**14,674**
soups (veg crop land)	**242,392**

As for energy land, the area of grazing and/or cropland required was converted into the equivalent 'global average productivity' land area using global equivalence factors (Table 3.4.9).

Table 3.4.9 Equivalence factors for converting different land use areas into land areas of global average productivity

Area	Equivalence factor [gha/ha]
Cropland	
primary cropland	**2.182**
marginal cropland	**1.768**
unharvested cropland	**2.182**
Pasture	**0.473**
Forest	**1.345**
Fishing grounds	**0.354**
Built	**2.182**
Hydro area	**1.000**
Energy	**1.345**

Examples of conversion factors for wholemilk and chocolate confectionery are provided in the tables below.

Table 3.4.10 Food and drink conversion factors for wholemilk

Wholemilk (1 tonne)	MJ/tonne	GWP/tonne ($t CO_2$ equiv)	Energy Land	Yield Factor (kg/ha)	Direct Land	Equivalence Factor	EF (ha/tonne)
Energy Land	**15,710**	**3.52**	**0.68**			**1.35**	**0.91**
Pasture Land				**336**	**2.978**	**0.47**	**1.41**
Total							2.32

Table 3.4.11 Food and drink conversion factors for chocolate confectionery

Chocolate confectionery (1 tonne)	MJ/tonne	GWP/tonne ($t CO_2$ equiv)	Energy Land	Yield Factor (kg/ha)	Direct Land	Equivalence Factor	EF (ha/t)
Energy Land	**36,055**	**6.58**	**1.26**			**1.35**	**1.70**
Grazing land (milk)				**168**	**5.957**	**0.47**	**2.82**
Crop land (sugar)				**12916**	**0.077**	**2.18**	**0.17**
Crop land (cocoa)				**816**	**1.226**	**2.18**	**2.68**
Total							7.36

The EF of food waste, distribution and packaging is also calculated, and is based on the GHG emissions associated with each of these areas (described above). Table 3.4.12 shows the EF of food supplies in the South East. In total the EF amounts to 16.6 million hectares or some 2 hectares per South East resident.

Table 3.4.12 Total Ecological Footprint of food supply in the South East (global hectares)

	Food and packaging production EF	Food Distribution EF	Land EF	Food Waste/Landfill EF	Total EF	EF/Capita
Households (HH)	**5,527,384**	**142,378**	**6,241,757**	**78,843**	**11,990,362**	**1.48**
HH food packaging	**524,177**		**80,227**		**604,404**	**0.07**
Restaurants and Commercial	**435,940**	**13,447**	**739,074**	**43,769**	**1,232,231**	**0.15**
Total	6,487,501	155,825	7,061,058	122,612	13,826,997	1.7
Total food waste (for information)	**1,219,618**	**33,121**	**1,567,027**		**2,819,765**	**0.35**

3.4.5 Material Flow Analysis (MFA) of food supply

The material inputs for food supply in the South East are summarised in the table below. In total 31.5 million tonnes of materials are involved, with the food that is consumed in the South East accounting for 15 per cent of these inputs. The material inputs amount to 3.9 tonnes per person.

Table 3.4.13 Material inputs for food supply

	Input (tonnes)	Animal based	Plant based	Water based	Energy Carriers (tonnes)	Hidden flows (tonnes)	Total MFA	Tonnes/ capita
Household	**4,347,483**	**1,515,575**	**2,195,984**	**635,924**	**4,412,496**	**11,733,260**	**20,493,238**	**2.53**
Restaurants and Commercial	**502,156**	**78,066**	**151,069**	**273,021**	**415,438**	**1,104,695**	**2,022,289**	**0.25**
Food packaging	**659,132**				**947,556**	**2,537,701**	**4,144,389**	**0.51**
Food waste	**1,081,753**	**302,525**	**467,529**	**311,700**	**1,025,467**	**2,726,827**	**4,834,048**	**0.60**
Total	6,590,525	1,896,166	2,814,582	1,220,645	6,800,957	18,102,483	31,493,965	3.88

Table 3.4.14 provides a detailed breakdown for food packaging by material type, together with energy carriers and hidden flows.

Table 3.4.14 Detailed breakdown of material inputs for food packaging

	Tonnage	Energy Carriers (tonnes)	Energy Carriers - Hidden Flows (tonnes)	Total MFA (tonnes)
Paper	**71,563**	**115,982**	**264,918**	**452,462**
Glass	**272,722**	**146,357**	**326,052**	**745,131**
Aluminium	**28,195**	**208,498**	**871,336**	**1,108,029**
Steel	**117,264**	**159,978**	**587,704**	**864,946**
Plastic	**169,389**	**316,741**	**487,692**	**973,821**
Packaging total	659,132	947,556	2,537,701	4,144,389

The material outputs are listed in the table below. These include 30.9 million tonnes of greenhouse gases (as CO_2 equivalent), 18 million tonnes of hidden flows, 659 thousand tonnes of packaging and 1 million tonnes of food waste.

Table 3.4.15 Outputs from the food system

Outputs	Tonnes
Carbon dioxide (inc methane as CO_2 equivalent)	**30,893,838**
Food waste	**1,081,753**
Hidden flows	**18,102,483**
Packaging, of which:	**659,132**
Paper	***71,563***
Glass	***272,722***
Aluminium	***28,195***
Steel	***117,264***
Plastic	***169,389***

3.5 Aggregates and Construction Materials

3.5.1 Introduction[42]

The UK recently adopted a strategy for more sustainable construction and has established institutions and procedures for improving the integration of environmental concerns into construction activities and policies (DTI 2003)[43]. In close cooperation with the industry, several initiatives for technology diffusion have been set up. With respect to material use, a quantified target to increase the use of construction waste and recycled aggregates was set: an increase of more than 80% by 2006, from the 1989 level. Landfilling of construction and demolition waste has fallen since the introduction of the landfill tax. The 2002 aggregates levy, which increased prices of sand, gravel and crushed rock by some 30%, is expected to provide an additional incentive for recycling. The 2001 climate change levy should help improve energy efficiency in commercial buildings. Standards for energy efficiency in new buildings have been raised gradually through the application of revised building regulations, and there is now more technical flexibility in meeting them. To improve energy efficiency in the existing housing stock, an investment programme targeted at "fuel poor" households was launched. In the private sector, builders now have to display energy ratings for new homes. The environmental performance of buildings is rated through the Building Research Establishment Environmental Assessment Method (BREEAM). Already applied to about 25% of new office buildings, this labelling system has helped raise awareness of energy efficiency issues.

However, there is still considerable scope for progress. Despite repeated upgrades, energy efficiency standards for new dwellings remain below those of comparable EU countries, while the large potential for improved energy efficiency in the existing building stock is only now beginning to be addressed. Translation of positive experiences from pilot projects into standard practice should be accelerated. Awareness of energy saving potential is still low. Rating and labelling systems for buildings, such as BREEAM, should be promoted more actively. The public sector has not yet fully integrated sustainable construction objectives into its procurement policies as regards construction. Concerning waste streams, information is insufficient to review the impact of recent measures, though there is growing concern about illegal disposal of construction and demolition waste at unlicensed sites. The sustainable construction strategy does not contain specific quantitative targets, but calls on the industry to measure baselines, set targets and publish results. The industry is developing sector and product-specific performance indicators, yet the development and use of environmental indicators needs to be encouraged further. Environmental and sustainable development concerns and criteria are often not sufficiently integrated into decisions on the design, construction, operation and assessment of buildings. Overall, the restructuring and reorientation of the sector has been driven primarily by economic priorities and perspectives.

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[42] Adapted from OECD (2002) Environmental Performance of the UK – Conclusions and Recommendations reviewed and approved by the Working Party on Environmental Performance at its meeting in June 2002.

[43] Department for Trade and Industry (2003) "Sustainable Construction" Website: http://www.dti.gov.uk/construction/sustain

3.5.2 Mining and construction activities in the South East – consumption of primary aggregates and construction materials

In order to explore the environmental impacts of constructional and building activities in the South East, an analysis of the consumption of aggregates and construction materials of South East residents as well as the associated ecological footprint was performed. The material flow analysis (MFA) comprised of the following categories:

- amount of primary aggregates consumed;
- hidden flows of materials associated with the extraction and production of aggregates;
- amount of construction materials and products consumed;
- embodied energy of all aggregates, materials and products (as energy carriers equivalents);
- energy for transport (as energy carriers equivalents);
- greenhouse gas emissions associated with energy use;
- waste produced within the construction sector.

All data relate to the year 2000 (if not otherwise stated).

Data sources

Original data about material consumption in the construction industry in the South East were used where possible. This was the case for most of the data on primary aggregates as it could be taken from the *Aggregate Minerals Survey for England and Wales*[44]. All other data were calculated by using PRODCOM using the procedure described below.

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. PRODCOM covers some 4,800 products which 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. The Standard Industrial Classification is used to classify business establishments and other statistical units by the type of economic activity in which they are engaged. The present 1992 revision is based on the activity classification issued by the Statistical Office of the European Communities (Eurostat), known as the NACE classification.

Those Standard Industrial Classifications which contain materials and products used by the construction industry are listed in Table 3.5.1. For a complete list of all PRODCOM items that together define the construction industry see Appendix A.2.

[44] ODPM (2002) Interim Results of the principal findings of the AM2001: Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

Table 3.5.1 SIC relating to construction materials and products

SIC[45]	Description
14	Quarry products
20	Wood products
24	Finishes, coatings and adhesive products
25	Plastic products
26	Products based on glass, ceramic, clay, cement, concrete, plaster, stone and other non-metallic minerals
28	Metal products
31	Cabling, wiring, lighting

This study follows the methodology of mass balance analysis as described in the 'Construction Industry Mass Balance' report produced by CIRIA and Viridis within the Biffaward Programme on Sustainable Resource Use (Smith et al. 2002[46]). From now on that report will be referred to as 'VR4' (Viridis Report VR4).

The PRODCOM annual reports (PRA) are published by the Office for National Statistics (ONS). They contain data on UK sales, imports and exports in both value and volume measure. From these data the actual consumption of each type of material/product can be derived. For this study PRODCOM data from the year 2000 were used.

The extended list of PRODCOM items for constructional use was clustered in superior groups as given in VR4, thus allowing a direct comparison of 2000 data (this study) with 1998 data (VR4). Table 3.5.2 shows all the data for the United Kingdom for all groups of products used in the construction industry.

Table 3.5.2 Primary materials used in construction in the UK 1998 and 2000

PRODCOM number & description of primary material / product	Total UK consumption in 1998 [tonnes]	Total UK consumption in 2000 [tonnes]	Notes
Quarry products			
141111: Marble and other building stone	304,715	304,715	a)
141112: Granite, sandstone, porphyr and basalt	3,404,031	3,404,031	a)
14121030: Gypsum and anhydrite	4,294,479	4,294,479	a)
14121050: Limestone etc.	18,104,562	17,361,507	b)
141220: Chalk and Dolomite	25,654,114	25,654,114	a)
14131000: Slate, crude, roughly trimmed or merely cut into rectangular or square blocks or slabs	405,496	454,203	b)
14211150/90: Construction sands (incl. silica sands)	50,213,418	51,936,949	b)
14211210: Gravel, pebbles, shingle and flint of a kind used for concrete aggregates, for road metalling or for railway or other ballast	37,057,828	36,594,736	b)
14211230: Crushed stone of a kind used for concrete aggregates, for roadstone and for other construction use	114,263,664	115,576,674	c)
14211250/90: Granules of stone	1,268,187	1,339,543	b)
14211350: Coated roadstone (tarred macadam)	22,906,396	21,022,145	b)
14221210: Bentonite etc.	11,500	11,500	a)
14221250: Common clays and shales for construction use (for bricks, tiles, pipes, cement)	12,281,124	12,281,124	a)

[45] Identical to the first two digits in the PRODCOM list

[46] Smith RA, Kersey JR, Griffith PJ (2002) The Construction Industry Mass Balance: resource use, wastes and emissions; Viridis Report VR4; CIRIA and Viridis

PRODCOM number & description of primary material / product	Total UK consumption in 1998 [tonnes]	Total UK consumption in 2000 [tonnes]	Notes
14501000: Natural bitumen and natural asphalt; asphaltites and asphaltic rocks	(suppressed)	(suppressed)	e)
14502340: Asbestos	1,795	244	b)
Total mass of quarry products	290,171,309	290,235,964	
Wood products			
20101010: Railway or tramway sleepers of wood	47,000	47,000	a)
20101032/34: Coniferous wood sawn or chipped lengthwise	479,000	528,728	d)
20101035: Spruce wood	1,930,000	5,249,242	d)
20101037: Pine wood	1,130,000	4,307,412	d)
20101039: Softwood sawn or chipped lengthwise	860,000	860,000	a)
20101050: Hardwood, sawn or chipped lengthwise	55,000	55,000	a)
20101071: Tropical wood sawn or chipped lengthwise	11,000	11,000	a)
20101077: Oak blocks	49,000	49,000	a)
201021: Wood continuously shaped, blocks, strips or freezes	664,000	197,080	b)
201031: Wood poles	154,000	154,000	a)
20103200: Railway or tramway sleepers (cross-ties) of impregnated wood	14,000	14,000	a)
202011/12: Plywood	878,500	960,421	d)
202013: Particle board	2,372,000	2,372,000	a)
202014: Fibreboard	527,000	765,245	d)
202021: Veneer sheets	30,400	30,400	a)
20202200: Densified wood	9,700	9,700	a)
203011: Windows and doors of wood	??	128,544	b)
203012: Parquet and shuttering of wood	30,000	40,823	c)
Total mass of wood products	9,240,600	15,779,594	
Finishes, coatings and adhesive products			
243011: Paints and varnishes	596,889	669,957	c)
243012: Other paints and varnishes	357,143	385,446	c)
24302253: Mastics	71,883	64,212	d)
24302255: Painters' fillings	28,652	28,652	a)
24302260: Non-refractory surfacing preparations	31,943	76,061	b)
24302273/79: Organic composite solvents	1,657	1,657	a)
246210: Glues	274,738	274,738	a)
24664867: Fire-proofing and water-proofing	97,000	87,542	d)
Total mass of finishes, coatings and adhesive products	1,459,905	1,588,265	
Plastic products			
252121/22: Plastic tubes, pipes and hoses	380,788	438,831	c)
252311: Plastic floor, wall and ceiling coverings	244,623	232,444	d)
252312: Plastic sanitary fixtures	3,397	8,214	b)
25231300: Plastic reservoirs, tanks and vats	9,911	9,911	a)
252314: Plastic windows, doors, blinds and shutters	673,362	673,362	a)
252315: Plastic fittings and mountings	79,360	79,360	a)
25242400: Plastic parts for lamps	10,941	10,941	a)
Total mass of plastic products	1,402,382	1,453,063	
Glass products			
2611: Flat Glass	1,223,263	1,223,263	a)
26121190: Decorative non-toughened flat glass	7,648	11,524	d)
26121230/70: Safety glass	414	288	d)
26121330: Multiple-walled insulating units of glass	331	298	d)
2614: Glass Fibres	171,766	126,527	b)
26151200: Other glass used for building or construction purposes	12,014	9,372	c)

PRODCOM number & description of primary material / product	Total UK consumption in 1998 [tonnes]	Total UK consumption in 2000 [tonnes]	Notes
Total mass of glass products	**1,415,436**	**1,371,272**	
Ceramic products			
2622: Ceramic Sanitary Fixtures	**57,250**	**45,635**	**b)**
2623: Ceramic Insulators and Insulating Fittings	**12,407**	**13,898**	**c)**
2630: Ceramic Tiles and Flags	**4,243,596**	**4,243,596**	**a)**
Total mass of ceramic products	**4,313,253**	**4,303,128**	
Bricks and other clay-based products			
26401110: Clay building bricks	**5,690,761**	**5,491,609**	**d)**
26401130: Clay flooring blocks, support or filler tiles and the like	**32,044**	**32,044**	**a)**
26401250: Clay roofing tiles	**163,391**	**179,938**	**d)**
26401270: Clay constructional products	**33,564**	**50,167**	**b)**
26401300: Clay pipes, conduits, guttering and pipe fittings	**59,650**	**128,641**	**b)**
Total mass of bricks and other clay-based products	**5,979,410**	**5,882,399**	
Cement, concrete and plaster products			
26511100: Cement clinker	**15,118,626**	**15,118,626**	**a)**
26511210: White Portland cement	**68,377**	**83,943**	**b)**
26511230: Grey Portland cement INCLUDING: - blended cement	**13,171,041**	**14,426,736**	**b)**
26511250: Alumina cement	**1,162,121**	**1,162,121**	**a)**
26511290: Other hydraulic cements	**1,512,804**	**1,812,422**	**b)**
26521033: Quicklime	**454,705**	**699,356**	**b)**
26521035: Slaked lime	**312,025**	**365,739**	**b)**
26521050: Hydraulic lime	**742,910**	**742,910**	**a)**
26531000: Plasters consisting of calcined gypsum or calcium sulphate	**1,104,587**	**1,031,726**	**b)**
26611130: Building blocks and bricks of cement, concrete or artificial stone	**15,808,401**	**14,148,998**	**b)**
26611150: Tiles, flagstones and similar articles of cement, concrete or artificial stone	**9,353,349**	**10,785,631**	**b)**
26611200: Prefabricated structural components for building or civil engineering, of cement, concrete or artificial stone	**3,568,914**	**4,186,788**	**b)**
26611300: Pipes of cement, concrete or artificial stone	**1,186,622**	**892,401**	**d)**
26612000: Prefabricated buildings of cement	**3,738,000**	**3,738,000**	**a)**
2662: Plaster Products for Construction Purposes	**2,420,892**	**2,650,680**	**d)**
26631000: Ready-mixed concrete	**53,089,942**	**53,089,942**	**a)**
26641000: Factory made mortars	**1,959,043**	**1,913,318**	**b)**
2665: Fibre Cement	**104,706**	**104,706**	**a)**
Total mass of cement, concrete and plaster products	**124,877,065**	**126,954,043**	
Stone and other non-metallic mineral products			
26701100: Worked monumental or building stone and articles thereof, of marble, travertine and alabaster	**76,319**	**70,257**	**c)**
26701210: Natural stone setts, kerbstones and flagstones	**92,265**	**131,963**	**b)**
26701230: Natural stone tiles, cubes and similar articles	**-**	**-**	**e)**
26701240: Worked calcareous monumental or building stone and articles thereof	**21,077**	**23,204**	**c)**
26701260: Worked monumental or building stone and articles thereof, of granite	**53,599**	**72,474**	**c)**
26701280: Worked monumental or building stone and articles thereof	**89,903**	**134,113**	**b)**
26701290: Worked slate and articles of slate or of agglomerated slate	**118,532**	**147,058**	**b)**
26821253: Roofing or waterproofing felts based on bitumen, in rolls	**12,633,213**	**10,558,828**	**d)**
26821259: Other products based on bitumen, in rolls	**2,235,378**	**2,235,378**	**a)**
26821290: Products based on bitumen not in rolls	**17,989**	**17,989**	**a)**

PRODCOM number & description of primary material / product	Total UK consumption in 1998 [tonnes]	Total UK consumption in 2000 [tonnes]	Notes
26821300: Bituminous mixtures based on natural and artificial aggregate and bitumen or natural asphalt as a binder	28,130,454	28,130,454	a)
26821630: Mixtures and articles of heat insulating, sound insulating or sound absorbing mineral materials	162,251	198,335	b)
Total mass of stone and other non-metallic mineral products	43,630,763	41,720,053	
Metal products			
281100: Constructional steel work and products	1,935,462	2,122,000	f)
281110: Iron or steel prefabricated buildings	463,454	491,341	c)
28112100: Iron or steel bridges and bridge-sections	50,832	62,090	c)
28112200: Iron or steel towers and lattice masts	8,175	8,175	a)
28112310: Iron or steel equipment for scaffolding, shuttering or propping	131,187	153,772	c)
28112330-60: Other structures of iron or steel	2,213,378	2,585,593	b)
28112370: Aluminium structures and parts of structures	55,754	61,113	b)
28121030/50: Doors and windows	234,952	23,134	b)
2822: Central Heating Radiators and Boilers	234,598	234,598	a)
2863: Locks and Hinges	136,840	141,511	c)
2874: Fasteners, Screw Machine Products, Chain and Spring	361,145	348,206	c)
2875: Other fabricated metal products	47,278	90,955	b)
Total mass of metal products	5,873,055	6,322,487	
Cabling, wiring, lighting			
3130: Insulated Wire and Cable	81,467	81,467	a)
3150: Lighting Equipment and Electric Lamps	108,152	108,152	a)
Total mass of cabling, wiring, lighting	189,619	189,619	
Overall Total	488,552,797	495,799,888	
Actual accuracy	*489 Mt*	*496 Mt*	

As not all PRODCOM data were available a number of adaptations and assumptions had to be made:

a)PRODCOM data for 2000 were missing partly or totally - data from the Viridis Report VR4 have been used instead.

b)Original PRODCOM 2000 data.

c)VR4 data were different from PRODCOM 1998 data (higher) - this difference was added to the PRODCOM 2000 data.

d)The same factor for converting a non-mass unit (e.g. m^3) into tonnes as used by VR4 was used in this study to convert PRODCOM 2000 data.

e)PRODCOM 2000 data were suppressed for this item.

f)Only PRODCOM 2000 SALES data were available (instead of consumption data).

Unlike in the VR4 report petroleum bitumen (23.10.30.00) was not included under "Finishes, Coatings and Adhesive Products" as it is totally incorporated into other products based on bitumen (26.82) and pre-coated aggregates (14.21.13.50).

Addressing double-counting

Some of the products listed above may occur twice in the PRODCOM categories as the list contains both precursor as well as successor materials and products. For example, quarrying activities provide primary aggregate materials such as sands and gravel which are used for ready mixed concrete and prefabricated concrete products. Another example is clay which is used as a raw material for bricks. Both categories – primary aggregates and manufactured materials/products – appear in the PRODCOM list. In quantifying the various components of the mass balance care has been taken by VR4 to avoid double-counting of resource use by identifying the flow of primary raw materials from extraction to their incorporation in construction products or construction works. The amount of primary aggregates like sands, gravel, limestone etc. incorporated in other products are recorded as part of the mass of that product and NOT as that of the primary aggregates. Thus the quantities

recorded as sands and gravels relate solely to those materials used in their original form. This approach also allows the use of material resources to be directly identified with their end use.

In this study double-counting is addressed in the same way by assuming that in 2000 the same percentage of materials is incorporated in other products as in 1998, i.e. VR4 data were adapted accordingly. Table 3.5.3 shows the results of these calculations.

Table 3.5.3 Total mass of primary materials and amount of these materials incorporated in successor products (double-counting correction) in the UK construction industry in the year 2000

PRODCOM number & description of primary material / product	Total UK consumption in 2000 [tonnes]	Double-counting correction 2000 a)
Quarry products		
141111: Marble and other building stone	304,715	- 304,715
14121030: Gypsum and anhydrite	4,294,479	- 4,294,479
14121050: Limestone etc.	17,361,507	- 17,361,507
14131000: Slate	454,203	- 132,770
14211150/90: Construction sands (incl. silica sands)	51,936,949	- 25,052,716
14211210: Gravel, pebbles, shingle and flint	36,594,736	- 27,411,590
14211230: Crushed stone	115,576,674	- 78,330,920
14221250: Common clays and shales for construction use	12,281,124	- 9,321,760
Total mass of quarry products	290,235,964	- 162,210,457
Actual accuracy	***290 Mt***	***162 Mt***
Cement, concrete and plaster products		
26511100: Cement clinker	15,118,626	- 15,118,626
26511210: White Portland cement	83,943	
26511230: Grey Portland cement	14,426,736	- 10,808,764
26511250: Alumina cement	1,162,121	
26511290: Other hydraulic cements	1,812,422	
26521033: Quicklime	699,356	
26521035: Slaked lime	365,739	- 304,224
26521050: Hydraulic lime	742,910	
26531000: Plasters	1,031,726	- 5,022
Total mass of cement, concrete and plaster products	126,954,043	- 26,236,636
Actual accuracy	***127 Mt***	***26.2 Mt***

a) Amount incorporated into successor materials

As stated above, petroleum bitumen (23.10.30.00) was not included under "Finishes, Coatings and Adhesive Products" as it is totally incorporated into other products based on bitumen (26.82) and pre-coated aggregates (14.21.13.50). Thus, in line with the procedure outlined above, only the successor products rather than the raw material is accounted for and no double-counting correction has to be made in this case.

Total material flows and ecological footprints were calculated before correcting double-counting (see below). The reason for this is that the extraction of aggregates are associated with hidden flows that would not be accounted for if these corrections were made prior to the calculations.

Apportioning consumption in the South East

As stated above, original data were only available for primary aggregates. Data on the consumption of other construction materials and products in the South East were estimated from national PRODCOM data using proportion factors. In order to give an appropriate picture of construction activities in the South East we decided to compile a set of proxy statistics from which we derived an average proportion factor for the South East. The proxies are building of new houses, expenditure on refurbishment and employment in the construction sector (see Table 3.5.4) and on average, 15.8% of the UK total was accounted for by the South East. Thus it was assumed that 15.8% of the UK's constructional activity in 2000 took place in the South East region and accordingly, all PRODCOM data were multiplied by the factor 0.158 to give South East regional data.

Table 3.5.4 Derivation of proportion factors specific to the South East construction industry

	Housebuilding completions 1998 [number of completions 1998] [a]	Expenditure on repairs, maintenance and decorations 2000 [million £] [b]	Number of employees in the construction sector 2000 [c]
United Kingdom	165,864	10,377	1,400,000
South East	24,012	1,528	256,000
Percentage SE/UK		14.7%	18.3%

a) Housebuilding completions by region, 1981 to 1998: Social Trends 30, Office for National Statistics UK. No more recent data available.

b) Detailed household expenditure by UK Countries and Government Office Region based on weighted data and including children's expenditure, 1998-2001

c) UK data: Construction Industry Board, State of the Construction Industry 2000. SE data: Office for National Statistics 2000

3.5.3 Calculating the material flows

The results of these proxy calculations, as well as the original data used in the following MFA and EF calculations, are presented in Table 3.5.5. Data for correcting double-counting are included as well.

Table 3.5.5 Primary materials used in construction in the South East in 2000

Primary Construction Material	Consumption in the South East [tonnes] [a]	Double-counting correction [tonnes] [a]	Hidden flows
Total mass of quarry products	47,761,127	-25,678,155	18,529,658
141111: Marble and other building stone	48,237	-48,237	11,592
141112: Granite, sandstone, porphyr and basalt	538,863		129,499
14121030: Gypsum and anhydrite	679,822	-679,822	135,964
14121050: Limestone etc.	2,748,352	- 2,748,352	660,482
141220: Chalk and Dolomite	4,061,084		975,957
… of which chalk	*39,000*	-	-
14131000: Slate, crude, roughly trimmed or merely cut into rectangular or square blocks or slabs	71,901	- 21,018	1,366,119
Total sand and gravel	19,524,000	-	7,709207
… of which land-won sand and gravel	*12,488,000*	-	*4,930,986*
… of which marine sand and gravel	*7,036,000*	-	*2,778,221*
… of which 14211150/90: Construction sands (incl. silica sands)	*8,221,696*	*- 3,965,882*	-

Primary Construction Material	Consumption in the South East [tonnes] [a)]	Double-counting correction [tonnes] [a)]	Hidden flows
… of which 14211210: Gravel, pebbles, shingle and flint of a kind used for concrete aggregates, for road metalling or for railway or other ballast	*5,793,001*	*- 4,339,295*	*-*
14211230: Crushed stone of a kind used for concrete aggregates, for roadstone and for other construction use	14,603,000	-12,399,901	3,500,010
... of which limestone (excluding dolomite)	*9,564,000*	*-*	*2,298,414*
... of which igneous rock (k) (l)	*4,725,000*	*-*	*1,135,509*
... of which dolomite (excluding limestone)	*275,000*	*-*	*66,088*
14211250/90: Granules of stone	212,052	-	50,960
14211350: Coated roadstone (tarred macadam)	3,327,837	-	799,743
14221210: Bentonite etc.	1,820	-	437
14221250: Common clays and shales for construction use (for bricks, tiles, pipes, cement)	1,944,120	- 1,475,648	3,189,676
14501000: Natural bitumen and natural asphalt; asphaltites and asphaltic rocks	(suppressed)	-	-
14502340: Asbestos	39	-	9
Total mass of wood products	2,497,933	-	-
20101010: Railway or tramway sleepers of wood	7,440	-	-
20101032/34: Coniferous wood sawn or chipped lengthwise	83,698	-	-
20101035: Spruce wood	830,963	-	-
20101037: Pine wood	681,870	-	-
20101039: Softwood sawn or chipped lengthwise	136,139	-	-
20101050: Hardwood, sawn or chipped lengthwise	8,707	-	-
20101071: Tropical wood sawn or chipped lengthwise	1,741	-	-
20101077: Oak blocks	7,757	-	-
201021: Wood continuously shaped, blocks, strips or freezes	31,198	-	-
201031: Wood poles	24,378	-	-
20103200: Railway or tramway sleepers (cross-ties) of impregnated wood	2,216	-	-
202011/12: Plywood	152,036	-	-
202013: Particle board	375,491	-	-
202014: Fibreboard	121,139	-	-
202021: Veneer sheets	4,812	-	-
20202200: Densified wood	1,536	-	-
203011: Windows and doors of wood	20,349	-	-
203012: Parquet and shuttering of wood	6,462	-	-
Total mass of finishes, coatings and adhesive products	251,425	-	-
243011: Paints and varnishes	106,055	-	-
243012: Other paints and varnishes	61,017	-	-
24302253: Mastics	10,165	-	-
24302255: Painters' fillings	4,536	-	-
24302260: Non-refractory surfacing preparations	12,041	-	-
24302273/79: Organic composite solvents	262	-	-
246210: Glues	43,491	-	-
24664867: Fire-proofing and water-proofing	13,858	-	-
Total mass of plastic products for construction	230,022	-	-
252121/22: Plastic tubes, pipes and hoses	69,468	-	-
252311: Plastic floor, wall and ceiling coverings	36,796	-	-
252312: Plastic sanitary fixtures	1,300	-	-
25231300: Plastic reservoirs, tanks and vats	1,569	-	-
252314: Plastic windows, doors, blinds and shutters	106,594	-	-
252315: Plastic fittings and mountings	12,563	-	-

Primary Construction Material	Consumption in the South East [tonnes] [a)]	Double-counting correction [tonnes] [a)]	Hidden flows
25242400: Plastic parts for lamps	1,732	-	-
		-	-
Total mass of glass products for construction	217,074	-	-
2611: Flat Glass	193,644	-	-
26121190: Decorative non-toughened flat glass	1,824	-	-
26121230/70: Safety glass	46	-	-
26121330: Multiple-walled insulating units of glass	47	-	-
2614: Glass Fibres	20,029	-	-
26151200: Other glass used for building or construction purposes (other than doors or windows)	1,484	-	-
Total mass of ceramic products for construction	681,192	-	-
2622: Ceramic Sanitary Fixtures	7,224	-	-
2623: Ceramic Insulators and Insulating Fittings	2,200	-	-
2630: Ceramic Tiles and Flags	671,768	-	-
Total mass of bricks and other clay-based products for construction	931,192	-	-
26401110: Clay building bricks	869,330	-	-
26401130: Clay flooring blocks, support or filler tiles and the like	5,073	-	-
26401250: Clay roofing tiles	28,484	-	-
26401270: Clay constructional products	7,942	-	-
26401300: Clay pipes, conduits, guttering and pipe fittings	20,364	-	-
Total mass of cement, concrete and plaster products for construction	20,097,013	- 4,153,298	-
26511100: Cement clinker	2,393,301	- 2,393,301	-
26511210: White Portland cement	13,288	-	-
26511230: Grey Portland cement INCLUDING:- blended cement	2,283,774	-1,711,043	-
26511250: Alumina cement	183,965	-	-
26511290: Other hydraulic cements	286,909	-	-
26521033: Quicklime	110,709	-	-
26521035: Slaked lime	57,897	-48,159	-
26521050: Hydraulic lime	117,604	-	-
26531000: Plasters consisting of calcined gypsum or calcium sulphate	163,324	- 795	-
26611130: Building blocks and bricks of cement, concrete or artificial stone	2,239,807	-	-
26611150: Tiles, flagstones and similar articles of cement, concrete or artificial stone	1,707,381	-	-
26611200: Prefabricated structural components for building or civil engineering, of cement, concrete or artificial stone	662,775	-	-
26611300: Pipes of cement, concrete or artificial stone	141,268	-	-
26612000: Prefabricated buildings of cement	591,731	-	-
2662: Plaster Products for Construction Purposes	419,607	-	-
26631000: Ready-mixed concrete	8,404,216	-	-
26641000: Factory made mortars	302,881	-	-
2665: Fibre Cement	16,575	-	-
Total mass of stone and other non-metallic mineral products	6,604,346	-	-
26701100: Worked monumental or building stone and articles thereof, of marble, travertine and alabaster	11,122	-	-
26701210: Natural stone sets, kerbstones and flagstones	20,890	-	-

Primary Construction Material	Consumption in the South East [tonnes] a)	Double-counting correction [tonnes] a)	Hidden flows
26701230: Natural stone tiles, cubes and similar articles	-	-	-
26701240: Worked calcareous monumental or building stone and articles thereof	3,673	-	-
26701260: Worked monumental or building stone and articles thereof, of granite	11,473	-	-
26701280: Worked monumental or building stone and articles thereof	21,230	-	-
26701290: Worked slate and articles of slate or of agglomerated slate	23,280	-	-
26821253: Roofing or waterproofing felts based on bitumen, in rolls	1,671,478	-	-
26821259: Other products based on bitumen, in rolls	353,864	-	-
26821290: Products based on bitumen not in rolls	2,848	-	-
26821300: Bituminous mixtures based on natural and artificial aggregate and bitumen or natural asphalt as a binder	4,453,093	-	-
26821630: Mixtures and articles of heat insulating, sound insulating or sound absorbing mineral materials	31,397	-	-
Total mass of metal products for construction	1,000,859	-	-
281100: Constructional steel work and products	335,916	-	-
281110: Iron or steel prefabricated buildings	77,780	-	-
28112100: Iron or steel bridges and bridge-sections	9,829	-	-
28112200: Iron or steel towers and lattice masts	1,294	-	-
28112310: Iron or steel equipment for scaffolding, shuttering, propping or pit-propping INCLUDING:- pit head frames and superstructures, adjustable/ telescopic props, tubular props (prop shafts), extensible coffering beams, tubular scaffolding and s	24,342	-	-
28112330-60: Other structures of iron or steel	409,303	-	-
28112370: Aluminium structures and parts of structures; aluminium plates, rods, profiles, tubes and the like, prepared for use in structures	9,674	-	-
28121030/50: Doors and windows	3,662	-	-
2822: Central Heating Radiators and Boilers	37,137	-	-
2863: Locks and Hinges	22,401	-	-
2874: Fasteners, Screw Machine Products, Chain and Spring	55,122	-	-
2875: Other fabricated metal products	14,398	-	-
Total mass of cabling, wiring, lighting	30,017	-	-
3130: Insulated Wire and Cable	12,896	-	-
3150: Lighting Equipment and Electric Lamps	17,121	-	-
Overall Total	**80,302,201**	**-29,831,454**	**18,529,658**
Actual Accuracy	**80.3 Mt**	**-29.8 Mt**	**18.5 Mt**

a) unless stated otherwise (see note b) all data are derived from PRODCOM data using a proxy of 15.8% for SE consumption

b) original data from the United Kingdom Minerals Yearbook 2001, British Geological Survey, Nottingham

c) original data from ODPM (2002) Interim Results of the principal findings of the AM2001: Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

According to these calculations **50.5 Mt** (80.3 Mt minus 29.8 Mt) of materials were used for constructional purposes in the South East in 2000[47]. Most of these materials are sand and gravel (19.5 Mt) and crushed stone (14.6 Mt). 8.4 Mt of concrete were used.

[47] some of the data being from 2001

The extraction of minerals and aggregates requires the movement of additional earth surface materials (overburden). These hidden flows were taken into account by multiplying the flows of quarry products (not double-counting corrected) with the multipliers given in Table 3.5.5. As there are no hidden flows associated with the manufacture of materials, no such calculations were done with all other constructional products (e.g. the quarrying of clay produces hidden material flows; the manufacture of bricks out of clay does not). The results of the hidden flow calculations are included in Table 3.5.6.

Table 3.5.6 Coefficients and multipliers for hidden flows of aggregates

Mineral	Hidden Flow Coefficient	Hidden Flow Multiplier
Clay	1.64	2.64
Crushed Stone	0.24	1.24
Gypsum	0.20	1.20
Sand & Gravel	0.39	1.39
Slate	19	20
Sand, silica & quartz	0.75	1.75
Petroleum/Oil	0.016	1.016

Sources: DEFRA 2002[48]; Douglas & Lawson 2001[49]

a) resulting in the hidden flow only

b) resulting in the total flow (material flow + hidden flow)

The extraction of minerals and aggregates as well as the manufacture of products needs energy (e.g. limestone – together with additives – has to be heated vigorously to produce cement[50]). This "embodied energy" was calculated by using the data given in Table 3.5.7.

Table 3.5.7 Embodied energy of different building materials, resulting carbon dioxide emissions and ecological footprint per tonne

Material	Embodied energy [GJ / tonne]	Tonne CO_2 per tonne [a] [tonnes]	Global EF [b] [gha / tonne]	Data source [c]
Aggregate (General)	0.10	0.01	0.002	CPBR
Aluminium (virgin)	191	14.33	3.71	CPBR
Bitumen	44.1	3.31	0.856	CPBR
Cement	7.80	0.59	0.151	CPBR
…cement mortar	2.00	0.15	0.039	CPBR
…fibre cement board	9.50	0.71	0.184	CPBR
…Portland	4.50	0.34	0.087	IVEM
…brick	2.50	0.19	0.049	CPBR
…floor brick	3.30	0.25	0.064	Thormark
…pipe	6.30	0.47	0.122	CPBR
…tile	2.50	0.19	0.049	CPBR
Concrete products	2.07	0.15	0.040	(CPBR)
…block	0.94	0.07	0.018	CPBR
…ready mix 30 Mpa	1.30	0.10	0.025	CPBR

[48] DEFRA (2000) *'Resource use and efficiency of the UK economy'*, A report by the Wuppertal Institute for Climate, Environment and Energy for Defra, http://www.defra.gov.uk/environment/statistics/des/waste/research/mfa/index.htm

[49] Douglas I, Lawson N; School of Geography, The University of Manchester (2001) "The Human Dimensions of Geomorphological Work in Britain", *Journal of Industrial Ecology*, 4(2): 9-33

[50] Worldwide production of cement accounts for 7 to 8 % of the total global anthropogenic CO_2 emissions (http://www.buildinggreen.com/features/flyash/appendixa.html)

Material	Embodied energy [GJ / tonne]	Tonne CO_2 per tonne [a] [tonnes]	Global EF [b] [gha / tonne]	Data source [c]
Glass	18.6	1.40	0.361	Thormark
…flat	21.0	1.58	0.408	IVEM
Gravel (broken)	0.19	0.01	0.004	IVEM
…fibreglass	30.3	2.27	0.588	CPBR
Lime	0.20	0.02	0.004	IVEM
Paint	90.4	6.78	1.75	CPBR
…solvent based	98.1	7.36	1.90	CPBR
Plaster (Gypsum)	4.50	0.34	0.087	CPBR
Plastics	79.0	5.93	1.53	Thormark
…HDPE	103	7.73	2.00	CPBR
…polypropylene	64.0	4.80	1.24	CPBR
…PVC	70.0	5.25	1.36	CPBR
Steel (virgin), general	32.0	2.40	0.621	CPBR
…wire rod	12.5	0.94	0.243	CPBR
Stone, dimension	3.60	0.27	0.070	Thormark
…local	0.79	0.06	0.015	CPBR
Timber / wood products	7.87	0.59	0.153	(CPBR)
...particle board	8.00	0.60	0.155	CPBR
…plywood	10.4	0.78	0.202	CPBR

a) calculated using the average CO_2 output per unit of energy mix as given in DUKES 2001[51] and DEFRA Reporting Guidelines for Company Reporting on Greenhouse Gas Emissions[52].

b) representing the notional 'energy land' (forests) required to sequester the CO_2 emissions.

c) CBPR: Alcorn J. A. (1998) Embodied Energy Coefficients of Building Materials, Centre for Building Performance Research, Wellington
IVEM: Interfacultaire Vakgroep Energie en Milieukunde, Energy Analysis Program, Research Report no.98, Groningen, March 1999

In order to obtain material flows for energy consumption, all embodied energy data have been converted to energy carriers and hidden flows of energy carriers using the conversion factors given in Table 3.5.8. Data from the EU were used when data from the UK were missing.

Table 3.5.8 Conversion factors for energy carriers and hidden flows of energy carriers of different industrial activities using UK and EU data on energy production (unit: GJ per tonne)

[GJ / tonne]	Construction (UK)	UK Mining and Quarrying (UK)	Wood and wood products (EU)	Chemical industry (incl. plastics) (EU)	Non-metallic minerals (incl. glass) (EU)	Iron and steel industry (EU)	Non-ferrous metals (incl. Al) (EU)	Machinery (incl. Electrical appliances) (EU)
Conversion factors - energy carriers (t/GJ)	0.028	0.023	0.053	0.028	0.033	0.045	0.041	0.037
Conversion factors - hidden flow for energy carriers (t/GJ)	0.019	0.00036	0.104	0.043	0.074	0.166	0.172	0.126

Construction materials have to be transported from the quarrying/mining sites or production sites to the actual construction sites. We calculated the energy for this transportation as well as the consequent carbon dioxide emissions. Three modes of freight transport were taken into account by using the UK

[51] DTI (2001) DUKES - Digest of United Kingdom Energy Statistics 2001
[52] http://www.defra.gov.uk/environment/envrp/gas/index.htm

freight mode breakdown: 72% of all freight is transported by lorries, 6% by trains and 21% by ships[53]. Specific energy carrier demand factors and emission factors for these three modes have been calculated for UK transport in general (see Chapter 3.3) and have been multiplied by the average distance the materials have been transported (see Table 3.5.9). Transport statistics only provide data on the amount of goods lifted (in Mt) and goods moved (in Mt-km) which result in an average length of haul. However, this is the length of just **one** transport stage. As some goods are lifted two or more times the actual transport distance is larger. Table 3.5.9 takes this fact into account by comparing consumption data to lift data. For the calculation of transport MF and EF the distances in the column 'Actual average length of total haul' were applied. The table also includes data on the number of empty running vehicles although this data has not been included in the calculations.

Table 3.5.9 Amount of freight goods lifted and moved in the UK in 2000 and average transport distances

Commodity	UK consump-tion [Mt] a)	Goods lifted [Mt]	lift factor b)	Tonne-kilometres of goods moved [Mt-km]	Average length of one haul trip [km]	Actual av. length of total haul [km]	Empty runs [%]
Wood, timber and cork	16	26	1.65	3,683	142	233	33.0
Sand, gravel and clay	101	113	1.12	4,074	36	40	43.7
Other crude minerals	189	195	1.03	8,329	43	44	42.8
Cements	33	76	2.33	2,522	33	77	48.5
Other building materials	53	89	1.67	8,074	91	152	30.5
Iron and steel products	n.a. c)	49	1.00	6,828	139	139	27.4
Other metal products	n.a. c)	16	1.00	1,667	104	104	31.5

Source: Transport Statistics Bulletin, Transport of Goods by Road in Great Britain 2000, Department of the Environment, Transport and the Regions: London, May 2001

a) derived from PRODCOM 2000 UK data

b) indicates how often a distinct amount of the good has been lifted

c) full PRODCOM data not available

For two primary aggregates – 'sand and gravel' and 'crushed rock' – more detailed data on imports into the South East region were available from the *Aggregate Minerals Survey for England and Wales*[54]. Table 3.5.10, part 1 to 3 shows these data as well as the results of the material flow calculations.

Table 3.5.10, part 1 Transport of primary aggregates in the South East: mass lifted, haul distances and resulting tonne-kilometres

Imported from …	Mass lifted a) [tonnes]	Haul distance b) [km]	Transport by lorry[tkm]	Transport by train[tkm]	Transport by ship [tkm]
Sand and gravel					
within SE	17,269,000	40	671,584,904	15,452,458	3,722,638
London	182,000	80	14,155,823	325,711	78,467
East of England	1,603,000	185	288,322,806	6,634,003	1,598,192
East Midlands	114,000	206	22,832,098	525,342	126,560
West Midlands	21,000	188	3,838,406	88,318	21,277
South West	331,000	320	102,979,722	2,369,454	570,823
North West	1,000	320	311,117	7,158	1,725

[53] derived from DETR, Focus on Freight 1998, UK Freight mode breakdown 1996

[54] ODPM (2002) Interim Results of the principal findings of the AM2001: Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

Imported from …	Mass lifted [a] [tonnes]	Haul distance [b] [km]	Transport by lorry[tkm]	Transport by train[tkm]	Transport by ship [tkm]
Yorks. & Humber	-	317	-	-	-
North East	3,000	444	1,295,024	29,797	7,178
South Wales	-	311	-	-	-
North Wales	-	338	-	-	-
Scotland	-	820	-	-	-
Europe	-	3,715	-	-	-
Total	19.5 Mt		1,105 Mt-km	25.4 Mt-km	6.13 Mt-km
Crushed rock					
within SE	1,861,000	40	74,440,000	-	-
London	-	80	-	-	-
East of England	2,500	185	462,500	-	-
East Midlands	1,727,000	206	355,762,000	-	-
West Midlands	6,500	188	1,222,000	-	-
South West	6,620,000	320	2,118,400,000	-	-
North West	-	320	-	-	-
Yorks. & Humber	500	317	158,500	-	-
North East	500	444	222,000	-	-
South Wales	204,000	311	63,444,000	-	-
North Wales	662,000	338	223,756,000	-	-
Scotland	2,815,200	820	2,309,691,427	-	-
Europe	703,800	3,715	2,614,695,826	-	-
Total	14.6 Mt		7,762 Mt-km	-	-

a) Source: ODPM (2002) Interim Results of the principal findings of the AM2001:Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

b) Haul distances were derived from road distances between major towns except for imports from Scotland and Europe where transport by ship was assumed (distances between Inverness as well as Marseille and major ports in SE England)

c) Transport modes for sand and gravel: 97.2% road, 2.2% rail and 0.5% water; for crushed rock: 100% road.

Table 3.5.10, part 2 Transport of primary aggregates in the South East: mass lifted, energy carrier (EC) demands and hidden flows of energy carriers

Imported from …	Mass lifted [a] [tonnes]	EC demand for lorries [b]: Diesel [tonnes]	EC demand for trains [c]: electricity / Diesel [tonnes]	EC demand for ships [d]: fuel oil [tonnes]	Hidden flows of all EC for transport [tonnes]
Sand and gravel					
within SE	17,269,000	159,959	182.6	48.4	2,573
London	182,000	3,372	3.8	1.0	54
East of England	1,603,000	68,673	78.4	20.8	1,105
East Midlands	114,000	5,438	6.2	1.6	87
West Midlands	21,000	914	1.0	0.3	15
South West	331,000	24,528	28.0	7.4	395
North West	1,000	74	0.1	0.0	1
Yorks. & Humber	-	-	-	-	-
North East	3,000	308	0.4	0.1	5
South Wales	-	-	-	-	-
North Wales	-	-	-	-	-
Scotland	-	-	-	-	-
Europe	-	-	-	-	-
	19.5 Mt	263,266 t	301 t	80 t	4,235 t
Crushed rock					

Imported from …	Mass lifted [a] [tonnes]	EC demand for lorries [b]: Diesel [tonnes]	EC demand for trains [c]: electricity / Diesel [tonnes]	EC demand for ships [d]: fuel oil [tonnes]	Hidden flows of all EC for transport [tonnes]
within SE	1,861,000	17,730	-	-	284
London	-	-	-	-	-
East of England	2,500	110	-	-	2
East Midlands	1,727,000	84,736	-	-	1,356
West Midlands	6,500	291	-	-	5
South West	6,620,000	504,563	-	-	8,073
North West	-	-	-	-	-
Yorks. & Humber	500	38	-	-	1
North East	500	53	-	-	1
South Wales	204,000	15,111	-	-	242
North Wales	662,000	53,294	-	-	853
Scotland	2,815,200	550,125	-	-	8,802
Europe	703,800	622,771	-	-	9,964
	14.6 Mt	1.85 Mt	-	-	0.0296 Mt

a) ODPM (2002) Interim Results of the principal findings of the AM2001:Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

b) Average energy carrier consumption factor for lorrys:238 g per tkm

c) Average energy carrier consumption factor for trains:11.8 g per tkm

d) Average energy carrier consumption factor for ships:13 g per tkm

Table 3.5.10, part 3 Transport of primary aggregates in the South East: mass lifted and CO_2 emissions by mode of transport

Imported from …	Mass lifted [a] [tonnes]	Emissions from road transport [b] [t CO_2]	Emissions from railway transport [c] [t CO_2]	Emissions from sea transport [d] [t CO_2]
Sand and gravel				
within SE	17,269,000	506,536	464	52
London	182,000	10,677	10	1
East of England	1,603,000	217,465	199	22
East Midlands	114,000	17,221	16	2
West Midlands	21,000	2,895	3	0
South West	331,000	77,671	71	8
North West	1,000	235	0	0
Yorks. & Humber	-	-	-	-
North East	3,000	977	1	0
South Wales	-	-	-	-
North Wales	-	-	-	-
Scotland	-	-	-	-
Europe	-	-	-	-
Total	19.5 Mt	833,676 t	763 t	86 t
Crushed rock				
within SE	1,861,000	56,146	-	-
London	-	-	-	-
East of England	2,500	349	-	-
East Midlands	1,727,000	268,330	-	-
West Midlands	6,500	922	-	-
South West	6,620,000	1,597,782	-	-
North West	-	-	-	-
Yorks. & Humber	500	120	-	-

Imported from …	Mass lifted [a] [tonnes]	Emissions from road transport [b] [t CO_2]	Emissions from railway transport [c] [t CO_2]	Emissions from sea transport [d] [t CO_2]
North East	500	167	-	-
South Wales	204,000	47,852	-	-
North Wales	662,000	168,766	-	-
Scotland	2,815,200	1,742,061	-	-
Europe	703,800	1,972,108	-	-
Total	14.6 Mt	5.85 Mt	-	-

a) ODPM (2002) Interim Results of the principal findings of the AM2001:Aggregate Minerals Survey for England and Wales (http://www.planning.odpm.gov.uk/am2001/index.htm)

b) Average CO_2 emission factor for lorrys:754 g per tkm

c) Average CO_2 emission factor for trains: 30 g per tkm

d) Average CO_2 emission factor for ships: 14 g per tkm

These calculations clearly show that transport has a major impact on the overall material flow (and thus the environment). Even though the amount of crushed stone consumed (14.6 Mt) is only 75% of the amount of sand and gravel (19.5 Mt), the energy carrier demand for road transport as well as the CO_2 emissions are seven times higher for stone (Table 3.5.11, part 2 and 3). This is because for the most part, sand and gravel (88%, or 17.3 Mt of 19.5 Mt) is sourced within the South East region and is transported only 40 kilometres on average. However, 87% of the crushed stone consumed in the South East (12.7 Mt of 14.6 Mt) is imported from other parts of Great Britain, and even Europe, which leads to high fuel consumption and emissions.

Energy carrier demands and CO_2 emissions of the transport of all other construction materials have been calculated in the same way (no data on imports were available for these materials however). Table 3.5.11 shows the energy carrier demands, associated hidden flows and CO_2 emissions for both embodied energy and transport, for all construction materials.

These results are probably an underestimate of the real material flows for several reasons:

- imports were neglected (only the movement of materials within the UK was taken into account)
- empty runs were neglected (about one third of all freight trips by road are accounted for by empty vehicles – the range for empty runs is from 25% for crude materials to 49% for cement)
- other GHG emissions than CO_2 emissions were neglected (CH_4, N_2O).

Table 3.5.11, part 1 Material flow of construction materials in South East England in 2000

Construction Materials (year 2000)	Embodied Energy [GJ]	Energy Carriers from embodied energy [t]	Hidden Flows of energy carriers from embodied energy [t]	Total Energy Carriers for Transport [t]	Hidden flows of Energy Carriers for Transport [t]
Total mass of quarry	16,369,101	372,652	5,960	2,216,576	35,506
141111: Marble etc	38,107	868	14	373	6.1
141112:	425,702	9,691	155	4,169	67.7
14121030: Gypsum etc	537,060	12,226	196	5,259	85.4
14121050: Limestone etc.	2,171,198	49,429	791	21,262	345
141220: Chalk & Dolomite	3,208,257	73,038	1,168	31,417	510
14131000: Slate crude	56,802	1,293	21	556	9
Total sand and gravel	2,830,980	64,449	1,031	263,646	4,235
… of which land-won	*1,810,760*	*41,223*	*659*		

Construction Materials (year 2000)	Embodied Energy [GJ]	Energy Carriers from embodied energy [t]	Hidden Flows of energy carriers from embodied energy [t]	Total Energy Carriers for Transport [t]	Hidden flows of Energy Carriers for Transport [t]
… of which marine sand	*1,020,220*	*23,226*	*371*		
14211230: Crushed stone	2,767,160	62,996	1,008	1,848,821	29,581
... of which limestone /	*1,817,160*	*41,369*	*662*		
... of which igneous rock	*897,750*	*20,438*	*327*		
... of which dolomite	*52,250*	*1,190*	*19*		
14211250/90: Stone pcs	167,521	3,814	61	1,640	27
14211350: Coated	2,628,991	59,850	957	25,745	418
14221210: Bentonite etc.	1,438	33	0.52	14.08	0.23
14221250: Common	1,535,855	34,965	559	13,673	222
14501000: Natural				-	-
14502340: Asbestos	31	0.69	0.011	0.299	0.005
				-	-
Total mass of wood	20,083,472	1,059,178	2,087,401	102,331	1,661
20101010: Railway etc	58,521	3,086	6,082	305	5
20101032/34: Coniferous	658,336	34,720	68,425	3,429	56
20101035: Spruce wood	6,535,997	344,701	679,327	34,042	553
20101037: Pine wood	5,363,295	282,854	557,441	27,934	454
20101039: Softwood	1,070,813	56,473	111,296	5,577	91
20101050:Hardwood	68,482	3,612	7,118	357	6
20101071: Tropical wood	13,696	722	1,424	71	1
20101077: Oak blocks	61,011	3,218	6,341	318	5
201021: Wood shaped	245,390	12,942	25,505	1,278	21
201031: Wood poles	191,750	10,113	19,930	999	16
20103200: Railway etc	17,432	919	1,812	91	1
202011/12: Plywood	1,581,175	83,389	164,341	6,228	101
202013: Particle board	3,003,929	158,424	312,217	15,383	250
202014: Fibreboard	952,830	50,251	99,034	4,963	81
202021: Veneer sheets	37,852	1,996	3,934	197	3
20202200: Densified	12,078	637	1,255	63	1
203011: Windows/doors	160,054	8,441	16,635	834	14
203012:	50,830	2,681	5,283	265	4
				-	-
Total mass of finishes	22,730,811	630,880	971,378	6,719	109
243011: Paints /	9,587,391	266,092	409,707	2,834	46
243012: Other paints	5,515,907	153,091	235,717	1,631	26
24302253: Mastics	918,901	25,504	39,268	272	4
24302255: Painters'	410,023	11,380	17,522	121	2
24302260: Non-refractory	1,088,464	30,210	46,514	322	5
24302273/79: Organic	25,732	714	1,100	7	0
246210: Glues	3,931,625	109,120	168,014	1,162	19
24664867: Fire-proofing	1,252,767	34,770	53,536	370	6
				-	-
Total mass of plastic	18,171,738	504,346	776,550	6,147	100
252121/22: Plastic tubes	5,487,934	152,314	234,521	1,857	30
252311: Plastic floor/wall	2,906,901	80,679	124,223	983	16
252312: Plastic sanitary	102,728	2,851	4,390	35	1
25231300:Plast.	123,945	3,440	5,297	42	1
252314: Windows/ doors	8,420,942	233,718	359,860	2,849	46
252315: Plastic fittings	992,462	27,545	42,412	336	5
25242400:Plastic for	136,826	3,798	5,847	46	1
				-	-
Total mass of glass	,741,052	157,104	349,994	5,801	94
2611: Flat Glass	4,066,531	134,752	300,200	5,175	84
26121190: Decorative	38,311	1,270	2,828	49	1
26121230/70: Safety	848	28	63	1	0

Construction Materials (year 2000)	Embodied Energy [GJ]	Energy Carriers from embodied energy [t]	Hidden Flows of energy carriers from embodied energy [t]	Total Energy Carriers for Transport [t]	Hidden flows of Energy Carriers for Transport [t]
26121330: Multiple-	877	29	65	1	0
2614: Glass Fibres	606,890	20,110	44,802	535	9
26151200: Other glass	27,595	914	2,037	40	1
				-	-
Total mass of ceramic	1,738,790	57,618	128,361	18,205	296
2622: Ceramic Sanitary	45,511	1,508	3,360	193	3
2623: Ceramic Insulators	13,860	459	1,023	59	1
2630: Ceramic Tiles etc	1,679,419	55,651	123,978	17,953	291
				-	-
Total mass of bricks	2,409,423	79,841	177,869	24,886	404
26401110: Clay building	2,173,325	72,017	160,439	23,233	377
26401130: Clay flooring	16,740	555	1,236	136	2
26401250: Clay roofing	71,211	2,360	5,257	761	12
26401270: Clay	19,854	658	1,466	212	3
26401300: Clay piping	128,294	4,251	9,471	544	9
				-	-
Total mass of cement	55,561,046	1,540,934	1,050,111	272,078	4,417
26511100: Cement	18,667,747	517,733	352,823	32,401	526
26511210: White Portland	59,797	1,658	1,130	180	3
26511230: Grey Portland	10,276,981	285,023	194,236	30,918	502
26511250: Alumina	1,434,931	39,796	27,120	2,491	40
26511290: Other	2,237,891	62,066	42,296	3,884	63
26521033: Quicklime	22,142	614	418	1,499	24
26521035: Slaked lime	11,579	321	219	784	13
26521050: Hydraulic lime	23,521	652	445	1,592	26
26531000: Plasters	734,957	20,383	13,891	2,211	36
26611130: Building	2,105,419	58,392	39,793	30,323	492
26611150:	3,526,363	97,800	66,649	23,115	375
26611200: Prefabricated	1,368,871	37,964	25,872	8,973	146
26611300: Cement pipes	291,771	8,092	5,515	1,913	31
26612000: Prefabricated	1,222,140	33,895	23,099	8,011	130
2662:Construction	1,888,230	52,368	35,688	5,681	92
26631000: Ready-mixed	10,925,481	303,008	206,493	113,778	1,847
26641000: Factory made	605,762	16,800	11,449	4,100	67
2665: Fibre Cement	157,464	4,367	2,976	224	4
				-	-
Total mass of stone	286,267,567	7,939,366	3,264,167	51,092	829
26701100: Worked	40,038	1,110	757	86	1.40
26701210: Natural stone	75,204	2,086	1,421	162	2.62
26701230: Natural stone	-	-	-	-	-
26701240: Calcareous	13,224	367	250	28	0.46
26701260: Worked	41,302	1,145	781	89	1.44
26701280: Worked stone	76,429	2,120	1,445	164	2.67
26701290: Worked slate	83,806	2,324	1,584	180	2.92
26821253: Roofing felts	73,712,186	2,044,339	1,393,170	12,931	209.93
26821259: Other	15,605,387	432,801	294,944	2,738	44.44
26821290: Other bitumin	125,583	3,483	2,374	22	0.36
26821300: Bitumin mixes	196,381,379	5,446,456	1,565,306	34,450	559.30
26821630: Mixtures	113,028	3,135	2,136	243	3.94
				-	-
Total mass of metal	33,565,701	1,511,893	5,592,626	24,460	397.12
281100: Constructional	10,749,304	486,602	1,787,606	8,210	133.28
281110: Iron/steel prefab	2,488,960	112,671	413,913	1,901	30.86
28112100: Iron/ste	314,526	14,238	52,306	240	3.90

Construction Materials (year 2000)	Embodied Energy [GJ]	Energy Carriers from embodied energy [t]	Hidden Flows of energy carriers from embodied energy [t]	Total Energy Carriers for Transport [t]	Hidden flows of Energy Carriers for Transport [t]
28112200: Iron/ste	41,412	1,875	6,887	32	0.51
28112310: Scaffolding	778,955	35,262	129,540	595	9.66
28112330-60: Other	13,097,702	592,909	2,178,143	10,003	162.40
28112370: Aluminium	1,847,787	76,080	317,947	236	3.84
28121030/50: Doors/wind	117,189	5,305	19,488	90	1.45
2822: Central Heating	1,188,391	53,796	197,629	908	14.74
2863: Locks and Hinges	716,843	32,450	119,211	547	8.89
2874:Fasteners/screws	1,763,889	79,848	293,334	1,347	21.87
2875: Other fabricated	460,744	20,857	76,622	352	5.71
				-	-
Total mass of cabling	375,212	13,770	47,107	549	8.91
3130: Insulated	161,204	5,916	20,239	236	3.83
3150: Lighting	214,008	7,854	26,868	313	5.08
-				-	-
Overall Total	462,013,913	13,867,583	16,597,851	2,728,846	43,823
Actual accuracy	462 PJ	13.9 Mt	16.6 Mt	2.73 Mt	0.0438 Mt

Table 3.5.11, part 2 Material flow of construction materials in South East England in 2000

Construction Materials (year 2000)	TOTAL Material Flow **(double-counting corrected)** [t]	TOTAL Material Flow per capita [t/cap]	CO2 from embodied energy [t CO_2] ('Product CO_2')	CO2 from transport [t CO_2]
Total mass of quarry	43,204,324	5.32	1,228,228	7,015,099
141111: Marble and other building stone	12,853	0.00	2,859	1,168
141112: Granite, sandstone, porphyr and	682,445	0.08	31,942	13,053
14121030: Gypsum and anhydrite	153,731	0.02	40,297	16,467
14121050: Limestone etc.	732,308	0.09	162,912	66,572
141220: Chalk and Dolomite	5,143,174	0.63	240,726	98,370
14131000: Slate, crude, roughly trimmed	1,418,882	0.17	4,262	1,742
Total sand and gravel	27,566,568	3.40	212,418	834,525
… of which land-won sand and gravel		-	*135,867*	
… of which marine sand and gravel		-	*76,551*	
14211230: Crushed stone for aggregates	7,606,516	0.94	207,629	5,854,601
... of which limestone / dolomite		-	*136,348*	
... of which igneous rock (k) (l)		-	*67,361*	
... of which dolomite (excluding limestone)		-	*3,920*	
14211250/90: Granules of stone	268,554	0.03	12,570	5,136
14211350: Coated roadstone (tarred	4,214,550	0.52	197,262	80,609
14221210: Bentonite etc.	2,306	0.00	108	44
14221250: Clays/shales for construction	3,707,566	0.46	115,240	42,811
14501000: Natural bitumen and asphalt etc	-	-		-
14502340: Asbestos	49	0.00	2.29	0.94
	-	-		-
Total mass of wood	5,748,504	0.71	1,506,930	320,409
20101010: Railway or tramway sleepers of	16,919	0.00	4,391	954
20101032/34: Coniferous wood sawn or	190,328	0.02	49,397	10,736
20101035: Spruce wood	1,889,585	0.23	490,418	106,587
20101037: Pine wood	1,550,551	0.19	402,426	87,463
20101039: Softwood sawn or chipped	309,577	0.04	80,347	17,463
20101050: Hardwood, sawn or chipped	19,799	0.00	5,138	1,117
20101071: Tropical wood sawn or chipped	3,960	0.00	1,028	223
20101077: Oak blocks	17,639	0.00	4,578	995
201021: Wood continuously shaped,	70,943	0.01	18,412	4,002
201031: Wood poles	55,436	0.01	14,388	3,127
20103200: Railway or tramway sleepers	5,040	0.00	1,308	284

Construction Materials (year 2000)	TOTAL Material Flow **(double-counting corrected)** [t]	TOTAL Material Flow per capita [t/cap]	CO2 from embodied energy [t CO_2] ('Product CO_2')	CO2 from transport [t CO_2]
202011/12: Plywood	**406,096**	**0.05**	**118,641**	**19,502**
202013: Particle board	**861,764**	**0.11**	**225,395**	**48,164**
202014: Fibreboard	**275,467**	**0.03**	**71,494**	**15,539**
202021: Veneer sheets	**10,943**	**0.00**	**2,840**	**617**
20202200: Densified wood	**3,492**	**0.00**	**906**	**197**
203011: Windows and doors of wood	**46,272**	**0.01**	**12,009**	**2,610**
203012: Parquet and shuttering of wood	**14,695**	**0.00**	**3,814**	**829**
	-	-		**-**
Total mass of finishes	**1,860,511**	**0.23**	**1,705,568**	**21,039**
243011: Paints and varnishes	**784,735**	**0.10**	**719,374**	**8,875**
243012: Other paints and varnishes	**451,481**	**0.06**	**413,877**	**5,106**
24302253: Mastics	**75,213**	**0.01**	**68,948**	**851**
24302255: Painters' fillings	**33,561**	**0.00**	**30,765**	**380**
24302260: Non-refractory surfacing	**89,092**	**0.01**	**81,671**	**1,008**
24302273/79: Organic composite solvents	**2,083**	**0.00**	**1,931**	**22**
246210: Glues	**321,807**	**0.04**	**295,003**	**3,639**
24664867: Fire-proofing and water-	**102,540**	**0.01**	**93,999**	**1,160**
	-	**-**		**-**
Total mass of plastic	**1,517,166**	**0.19**	**1,363,486**	**19,248**
252121/22: Plastic tubes, pipes and hoses	**458,190**	**0.06**	**411,778**	**5,813**
252311: Plastic floor, wall and ceiling	**242,698**	**0.03**	**218,115**	**3,079**
252312: Plastic sanitary fixtures	**8,577**	**0.00**	**7,708**	**109**
25231300: Plastic reservoirs, tanks and	**10,348**	**0.00**	**9,300**	**131**
252314: Plastic windows, doors, blinds etc	**703,068**	**0.09**	**631,851**	**8,920**
252315: Plastic fittings and mountings	**82,861**	**0.01**	**74,468**	**1,051**
25242400: Plastic parts for lamps	**11,424**	**0.00**	**10,267**	**145**
	-	**-**		**-**
Total mass of glass	**730,068**	**0.09**	**355,737**	**18,164**
2611: Flat Glass	**633,856**	**0.08**	**305,125**	**16,204**
26121190: Decorative non-toughened flat	**5,972**	**0.00**	**2,875**	**153**
26121230/70: Safety glass	**138**	**0.00**	**64**	**4**
26121330: Multiple-walled insulating units	**142**	**0.00**	**66**	**4**
2614: Glass Fibres	**85,486**	**0.01**	**45,537**	**1,676**
26151200: Other glass used for	**4,475**	**0.00**	**2,071**	**124**
	-	**-**		**-**
Total mass of ceramic	**885,671**	**0.11**	**130,467**	**57,001**
2622: Ceramic Sanitary Fixtures	**12,288**	**0.00**	**3,415**	**604**
2623: Ceramic Insulators and Insulating	**3,742**	**0.00**	**1,040**	**184**
2630: Ceramic Tiles and Flags	**869,641**	**0.11**	**126,012**	**56,212**
	-	**-**		**-**
Total mass of bricks	**1,214,192**	**0.15**	**180,787**	**77,920**
26401110: Clay building bricks	**1,125,396**	**0.14**	**163,072**	**72,744**
26401130: Clay flooring blocks, support	**7,001**	**0.00**	**1,256**	**424**
26401250: Clay roofing tiles	**36,875**	**0.00**	**5,343**	**2,384**
26401270: Clay constructional products	**10,281**	**0.00**	**1,490**	**665**
26401300: Clay pipes, conduits, guttering	**34,639**	**0.00**	**9,626**	**1,704**
	-	-		**-**
Total mass of cement	**18,811,256**	**2.32**	**4,168,930**	**851,904**
26511100: Cement clinker	**903,483**	**0.11**	**1,400,703**	**101,451**
26511210: White Portland cement	**16,260**	**0.00**	**4,487**	**563**
26511230: Grey Portland cement	**1,083,410**	**0.13**	**771,116**	**96,808**
26511250: Alumina cement	**253,413**	**0.03**	**107,668**	**7,798**
26511290: Other hydraulic cements	**395,219**	**0.05**	**167,916**	**12,162**
26521033: Quicklime	**113,265**	**0.01**	**1,661**	**4,693**
26521035: Slaked lime	**11,075**	**0.00**	**869**	**2,454**

Construction Materials (year 2000)	TOTAL Material Flow **(double-counting corrected)** [t]	TOTAL Material Flow per capita [t/cap]	CO2 from embodied energy [t CO_2] ('Product CO_2')	CO2 from transport [t CO_2]
26521050: Hydraulic lime	**120,319**	**0.01**	**1,765**	**4,985**
26531000: Plasters of gypsum/calcium	**199,050**	**0.02**	**55,146**	**6,923**
26611130: Cement/concrete building	**2,368,807**	**0.29**	**157,977**	**94,944**
26611150: Tiles, flagstones and similar	**1,895,321**	**0.23**	**264,595**	**72,375**
26611200: Prefabricated building	**735,729**	**0.09**	**102,711**	**28,095**
26611300: Pipes of cement, concrete etc	**156,819**	**0.02**	**21,893**	**5,988**
26612000: Prefab buildings of cement	**656,866**	**0.08**	**91,701**	**25,083**
2662: Plaster Products for Construction	**513,436**	**0.06**	**141,680**	**17,787**
26631000: Ready-mixed concrete	**9,029,343**	**1.11**	**819,775**	**356,251**
26641000: Factory made mortars	**335,297**	**0.04**	**45,452**	**12,839**
2665: Fibre Cement	**24,146**	**0.00**	**11,815**	**703**
	-	**-**		**-**
Total mass of stone	**17,859,801**	**2.20**	**21,479,610**	**159,975**
26701100: Worked monumental or building	**13,076**	**0.00**	**3,004**	**269**
26701210: Natural stone setts, kerbstones	**24,561**	**0.00**	**5,643**	**506**
26701230: Natural stone tiles, cubes etc	**-**	**-**	**-**	**-**
26701240: Worked calcareous monumental	**4,319**	**0.00**	**992**	**89**
26701260: Worked articles of granite	**13,489**	**0.00**	**3,099**	**278**
26701280: Other worked stone articles	**24,961**	**0.00**	**5,735**	**514**
26701290: Worked slate and articles of	**27,371**	**0.00**	**6,288**	**564**
26821253: Roofing or waterproofing felts	**5,122,128**	**0.63**	**5,530,871**	**40,488**
26821259: Other products - bitumen rolls	**1,084,390**	**0.13**	**1,170,924**	**8,572**
26821290: Bitumin products not in rolls	**8,727**	**0.00**	**9,423**	**69**
26821300: Bituminous mixtures	**11,499,864**	**1.42**	**14,735,150**	**107,866**
26821630: Mixtures for heat/sound	**36,915**	**0.00**	**8,481**	**761**
	-	**-**		**-**
Total mass of metal	**,130,235**	**1.00**	**2,518,546**	**76,587**
281100: Constructional steel work/	**2,618,466**	**0.32**	**806,556**	**25,705**
281110: Iron or steel prefabricated	**606,296**	**0.07**	**186,755**	**5,952**
28112100: Iron or steel bridges & sections	**76,617**	**0.01**	**23,600**	**752**
28112200: Iron or steel towers/ lattice	**10,088**	**0.00**	**3,107**	**99**
28112310: Iron or steel scaffolding etc	**189,749**	**0.02**	**58,448**	**1,863**
28112330-60: Other structures of iron or	**3,190,522**	**0.39**	**982,764**	**31,320**
28112370: Aluminium structures, plates	**403,942**	**0.05**	**138,646**	**740**
28121030/50: Doors and windows	**28,547**	**0.00**	**8,793**	**280**
2822: Central Heating Radiators and	**289,485**	**0.04**	**89,169**	**2,842**
2863: Locks and Hinges	**174,619**	**0.02**	**53,787**	**1,714**
2874: Fasteners, Machine products etc	**429,673**	**0.05**	**132,350**	**4,218**
2875: Other fabricated metal products	**112,234**	**0.01**	**34,571**	**1,102**
	-	**-**		**-**
Total mass of cabling	**91,452**	**0.01**	**28,153**	**1,719**
3130: Insulated Wire and Cable	**39,291**	**0.00**	**12,096**	**738**
3150: Lighting Equipment and Electric	**52,161**	**0.01**	**16,058**	**980**
-	**-**	**-**		**0**
Overall Total	**100,053,180**	**12.33**	**34,666,444**	**8,619,065**
Actual accuracy	**100 Mt**	**12.3 t/cap**	**34.7 Mt**	**8,62 Mt**

The total material flow of construction materials in the South East including all energy carriers and hidden flows is 100 megatonnes. This means that every South East resident used 12.3 tonnes of materials on average for constructional purposes. If no corrections for double-counting were made, the total flow would be 130 Mt as 30 Mt of aggregates were converted to constructional products (both of which are included in the PRODCOM list).

In order to produce all construction materials, 462 petajoules of energy were used. This required 13.9 Mt of energy carriers and even more (14.5 Mt) of hidden flows, due to the large amounts of hidden flows associated with the extraction of coal used for electricity production. In order to transport the materials, 2.73 Mt of fuels were used (with 43.8 kt of hidden flows).

CO_2 emissions arose from both production (34.7 Mt from embodied energy) and transport (8.62 Mt).

3.5.4 Calculating the ecological footprint

The ecological footprint of the consumption of construction materials was calculated as 'carbon land' area (i.e. the notional land area required in absorbing the carbon dioxide (CO_2) produced by the combustion of fuels). This is according to the methodology described in the chapters for freight and passenger transport with two exceptions:

- only CO_2 was taken into account (thus neglecting the impact of methane and nitrous oxide);
- no built land area was taken into account.

CO_2 emission factors for different modes of freight transport are given in Chapter 3.3 (freight transport). Table 3.5.12 shows the results of the EF calculations for all construction materials.

Table 3.5.12 Ecological footprint of construction materials in South East England in 2000

Construction Materials	Product CO_2 EF [gha]	Transport CO_2 EF [gha]	Total EF [gha]	Total EF per capita [gha/cap]
Total mass of quarry products	**317,752**	**1,814,861**	**2,132,613**	**0.2628**
141111: Marble and other building stone	740	302	1,042	0.0001
141112: Granite, sandstone, porphyr and basalt	8,264	3,377	11,640	0.0014
14121030: Gypsum and anhydrite	10,425	4,260	14,685	0.0018
14121050: Limestone etc.	42,147	17,223	59,369	0.0073
141220: Chalk and Dolomite	62,278	25,449	87,727	0.0108
14131000: Slate, crude, roughly trimmed etc	1,103	451	1,553	0.0002
Total sand and gravel	54,954	215,898	270,852	0.0334
… of which land-won sand and gravel	*35,150*			-
… of which marine sand and gravel	*19,804*			-
14211230: Crushed stone used for concrete	53,715	1,514,631	1,568,346	0.1933
... of which limestone / dolomite	*35,274*			-
... of which igneous rock (k) (l)	*17,427*			-
... of which dolomite (excluding limestone)	*1,014*			-
14211250/90: Granules of stone	3,252	1,329	4,581	0.0006
14211350: Coated roadstone (tarred macadam)	51,033	20,854	71,887	0.0089
14221210: Bentonite etc.	28	11	39	0.0000
14221250: Clays and shale's for construction	29,814	11,075	40,889	0.0050
14501000: Natural bitumen and natural asphalt		-		-
14502340: Asbestos	0.59	0.24	0.83	0.0000
Total mass of wood products	**389,854**	**82,892**	**472,747**	**0.0583**
20101010: Railway or tramway sleepers of wood	1,136	247	1,383	0.0002
20101032/34: Coniferous wood sawn or chipped	12,779	2,777	15,557	0.0019
20101035: Spruce wood	126,875	27,575	154,450	0.0190
20101037: Pine wood	104,111	22,627	126,738	0.0156
20101039: Softwood sawn or chipped	20,786	4,518	25,304	0.0031
20101050: Hardwood, sawn or chipped	1,329	289	1,618	0.0002
20101071: Tropical wood sawn or chipped	266	58	324	0.0000
20101077: Oak blocks	1,184	257	1,442	0.0002
201021: Wood continuously shaped, blocks,	4,763	1,035	5,799	0.0007
201031: Wood poles	3,722	809	4,531	0.0006
20103200: Railway or tramway sleepers (cross-	338	74	412	0.0001
202011/12: Plywood	30,693	5,045	35,739	0.0044
202013: Particle board	58,311	12,460	70,772	0.0087
202014: Fibreboard	18,496	4,020	22,516	0.0028
202021: Veneer sheets	735	160	894	0.0001
20202200: Densified wood	234	51	285	0.0000
203011: Windows and doors of wood	3,107	675	3,782	0.0005
203012: Parquet and shuttering of wood	987	214	1,201	0.0001
Total mass of finishes, coatings and adhesive	**441,244**	**5,443**	**446,687**	**0.0550**
243011: Paints and varnishes	186,108	2,296	188,404	0.0232
243012: Other paints and varnishes	107,073	1,321	108,394	0.0134
24302253: Mastics	17,837	220	18,057	0.0022
24302255: Painters' fillings	7,959	98	8,057	0.0010
24302260: Non-refractory surfacing	21,129	261	21,390	0.0026
24302273/79: Organic composite solvents	500	6	505	0.0001
246210: Glues	76,320	942	77,261	0.0095
24664867: Fire-proofing and water-proofing	24,318	300	24,618	0.0030
Total mass of plastic products for construction	**352,744**	**4,980**	**357,724**	**0.0441**

Construction Materials	Product CO_2 EF [gha]	Transport CO_2 EF [gha]	Total EF [gha]	Total EF per capita [gha/cap]
252121/22: Plastic tubes, pipes and hoses	106,530	1,504	108,034	0.0133
252311: Plastic floor, wall and ceiling coverings	56,428	797	57,224	0.0071
252312: Plastic sanitary fixtures	1,994	28	2,022	0.0002
25231300: Plastic reservoirs, tanks and vats	2,406	34	2,440	0.0003
252314: Plastic windows, doors, blinds and	163,465	2,308	165,772	0.0204
252315: Plastic fittings and mountings	19,265	272	19,537	0.0024
25242400: Plastic parts for lamps	2,656	37	2,694	0.0003
Total mass of glass products for construction	92,032	4,699	96,731	0.0119
2611: Flat Glass	78,938	4,192	83,130	0.0102
26121190: Decorative non-toughened flat glass	744	39	783	0.0001
26121230/70: Safety glass	16	1	17	0.0000
26121330: Multiple-walled insulating units of	17	1	18	0.0000
2614: Glass Fibres	11,781	434	12,214	0.0015
26151200: Other glass used for construction	536	32	568	0.0001
Total mass of ceramic products for construction	33,753	14,747	48,499	0.0060
2622: Ceramic Sanitary Fixtures	883	156	1,040	0.0001
2623: Ceramic Insulators and Insulating Fittings	269	48	317	0.0000
2630: Ceramic Tiles and Flags	32,600	14,543	47,143	0.0058
Total mass of bricks and other clay-based products	46,771	20,159	66,930	0.0082
26401110: Clay building bricks	42,188	18,819	61,007	0.0075
26401130: Clay flooring blocks, support or filler	325	110	435	0.0001
26401250: Clay roofing tiles	1,382	617	1,999	0.0002
26401270: Clay constructional products	385	172	557	0.0001
26401300: Clay pipes, conduits, guttering and	2,490	441	2,931	0.0004
Total mass of cement, concrete and plaster	1,078,535	220,394	1,298,929	0.1601
26511100: Cement clinker	362,373	26,246	388,619	0.0479
26511210: White Portland cement	1,161	146	1,306	0.0002
26511230: Grey Portland cement	199,494	25,045	224,539	0.0277
26511250: Alumina cement	27,854	2,017	29,872	0.0037
26511290: Other hydraulic cements	43,441	3,146	46,588	0.0057
26521033: Quicklime	430	1,214	1,644	0.0002
26521035: Slaked lime	225	635	860	0.0001
26521050: Hydraulic lime	457	1,290	1,746	0.0002
26531000: Plasters consisting of calcined	14,267	1,791	16,058	0.0020
26611130: Building blocks and bricks of cement	40,870	24,563	65,433	0.0081
26611150: Tiles, flagstones and similar articles	68,453	18,724	87,177	0.0107
26611200: Prefabricated structural components	26,572	7,268	33,840	0.0042
26611300: Pipes of cement, concrete etc	5,664	1,549	7,213	0.0009
26612000: Prefabricated buildings of cement	23,724	6,489	30,213	0.0037
2662: Plaster Products for Construction	36,654	4,602	41,255	0.0051
26631000: Ready-mixed concrete	212,082	92,165	304,247	0.0375
26641000: Factory made mortars	11,759	3,322	15,080	0.0019
2665: Fibre Cement	3,057	182	3,238	0.0004
Total mass of stone and other non-metallic mineral	3,876,296	41,387	3,917,683	0.4799
26701100: Worked monumental or building	777	70	847	0.0001
26701210: Natural stone sets, kerbstones etc	1,460	131	1,591	0.0002
26701230: Natural stone tiles, cubes etc	-	-	-	-
26701240: Worked calcareous monumental	257	23	280	0.0000
26701260: Worked articles of granite	802	72	874	0.0001

Construction Materials	Product CO_2 EF [gha]	Transport CO_2 EF [gha]	Total EF [gha]	Total EF per capita [gha/cap]
26701280: Other worked stone & articles	1,484	133	1,617	0.0002
26701290: Worked slate and articles of slate	1,627	146	1,773	0.0002
26821253: Roofing felts - bitumen, in rolls	1,430,879	10,474	1,441,354	0.1776
26821259: Other bitumin products, in rolls	302,927	2,218	305,145	0.0376
26821290: Bitumin products not in rolls	2,438	18	2,456	0.0003
26821300: Bituminous mixtures	2,131,452	27,906	2,159,358	0.2632
26821630: Mixtures and heat/sound insulation	2,194	197	2,391	0.0003
Total mass of metal products for construction	651,568	19,814	671,381	0.0827
281100: Constructional steel work and products	208,662	6,650	215,312	0.0265
281110: Iron or steel prefabricated buildings	48,315	1,540	49,855	0.0061
28112100: Iron or steel bridges & bridge-	6,105	195	6,300	0.0008
28112200: Iron or steel towers and lattice masts	804	26	829	0.0001
28112310: Iron/ steel equipment for scaffolding	15,121	482	15,603	0.0019
28112330-60: Other structures of iron or steel	254,249	8,103	262,352	0.0323
28112370: Aluminium structures, plates, rods	35,869	192	36,060	0.0044
28121030/50: Doors and windows	2,275	72	2,347	0.0003
2822: Central Heating Radiators and Boilers	23,069	735	23,804	0.0029
2863: Locks and Hinges	13,915	443	14,359	0.0018
2874: Fasteners, Screw Machine Products etc	34,240	1,091	35,331	0.0044
2875: Other fabricated metal products	8,944	285	9,229	0.0011
Total mass of cabling, wiring, lighting	7,284	445	7,728	0.0010
3130: Insulated Wire and Cable	3,129	191	3,320	0.0004
3150: Lighting Equipment and Electric Lamps	4,154	254	4,408	0.0005
Overall Total	**7,287,833**	**2,229,819**	**9,517,652**	**1.173**
Actual accuracy	**7.29 million gha**	**2.23 million gha**	**9.52 million gha**	**1.17 gha/cap**

The embodied energy of construction materials accounted for 80% of the ecological footprint, the remainder (20%) being due to their transport. All together an EF of 11.2 million hectares is needed to provide South East England with construction materials within one year. This is equivalent to a footprint of 1.38 global hectares per capita.

3.6 Consumable and Disposable Products

3.6.1 Introduction

In 1999 the Total Material Requirement (TMR) of the UK was 40 tonnes per person (excluding soil erosion) (DEFRA 2002)[55]. From 1970 to 1999, TMR per capita grew by 5 % which, after taking into account the population increase, represents an absolute increase of 12 %. Since 1990, the UK's TMR has no longer been growing in either per capita or absolute terms. The UK has also increased its burden on other countries through increasing levels of imports. The industrialised countries have succeeded in passing on environmental burdens to less developed countries, leaving the noise, dirt and the pollution for the industrial areas of the world (ETC-WMF 2003)[56]. In other words, the geographic location of environmental pressures has little relation to the location of consumption. According to a recent study published by the European Topic Centre on Waste and Material Flows, this phenomenon is increasing. The 'Zero Study' (ETC-WMF 2003)[56] suggests that there has been a significant shift in resource requirements from domestic production to imports, thus shifting the environmental burden of resource consumption onto other countries. Therefore, while environmental standards may have improved in the UK, the UK as a whole has not reduced its environmental burden within a global context. It is no longer possible to purely consider the impact of production in the UK when a vast majority of the production that is undertaken for the UK takes places elsewhere. It is only in a resource perspective where excessive consumption is defined as the critical problem that industrialised countries have to respond to.

This section considers the consumption of the South East residents, whether directly through the purchase of goods or indirectly through services. This section includes consumable items whereas the next section (3.7) deals with durable products. Beyond this the sections have been broken down further into product and material types.

[55] DEFRA (2002) *Resource use and efficiency of the UK economy* – A report by the Wuppertal Institute for the UK Department of Environment, Food and Rural Affairs, London

[56] ETC-WMF (2003) *Zero Study: Resource Use in European Countries* – An estimate of materials and waste streams in the Community, including imports and exports using the instrument of material flow analysis, European Topic Centre on Waste and Material Flows, Copenhagen

3.6.2 Methodological issues

A range of methods has been employed in an attempt to establish an accurate picture of material consumption in the South East. National data sets, produced by ONS, were used along with information gathered from trade associations. At every opportunity a data sensitivity analysis has been conducted in an effort to support the assumptions. For example, when calculating the consumption of pet food, the PRODCOM database provided total consumption for the UK which was then proportioned to the South East using the Household Expenditure Survey. The Pet Food Manufacturer's Association was contacted and provided supporting evidence for our assumptions. In some cases it has also been possible to cross-check our figures with waste data for the region. Every effort has been made to ensure the final result is an accurate representation of consumption. Details of the references employed for each consumer item have been provided below.

Dr. Philip Sinclair from Surrey University constructed a model that provided some of the data for domestic consumables. The results of this approach were then analysed and adjusted by SEI verifying the data with other data from a range of sources. A description of the approach adopted by Surrey University has been given below.

The approach employed by Surrey University to provide a guide to material consumption was based on the use of a national database PRODCOM. PRODCOM provides prices in £/kg for a range of domestic consumable products. The estimates included labour as well as capital meaning that percentages for labour were derived and the necessary adjustments made. Estimates of the lifetime in years of the products were also undertaken. With the use of the Household Expenditure Survey, weekly household expenditure for the South East was used as a proxy to assign consumption for the South East. The methodology described in Chapter 2 has been employed, i.e. the embodied energy, energy carriers and hidden flows of each material have been calculated. The use of PRODCOM provides consistency and comparability across studies. The study has attempted to use the national accounts wherever possible[57].

Expenditure on luxury items in the South East is relatively high. The average South East household spends more on clothing, furniture and toiletries than any other region in the UK. This culminates in a greater number of goods being delivered to the South East and higher levels of industrial activity in the production of these goods. However, over 90 per cent of these "luxury" items are not produced in the South East, the majority being produced in developing countries. As with the section concerning food, this section has attempted to link the inputs to the South East with the outputs, demonstrating a clear link with the metabolism of the region. A substantial amount of work has been completed on the material composition of all the consumer items. This has involved extensive correspondence with trade associations and manufacturers in an attempt to establish a clear picture of the impact of the various consumer items.

3.6.3 Paper products

The analysis for households considered the consumption of books, newspapers, periodicals and magazines, greetings cards, stationery and other paper goods[58]. An analysis of paper consumption by commercial services and public administration was also undertaken. A description of paper packaging has been given in the packaging section, however the figure has also been given below.

[57] The authors of the report will happily provide more details of the methodology on request.
[58] See Chapter 5 for an analysis of paper production in the South East.

Table 3.6.1 shows the results of the material flow analysis for paper and paper products.

Table 3.6.1 Material flow analysis of paper consumption in the South East

Category	Amount consumed (tonnes)	Embodied energy (GJ)	Energy carriers (tonnes)	Hidden flows of energy carriers (tonnes)	Total Material Requirement (tonnes)	GWP (tonnes CO_2 equivalent))
Greetings cards, stationery and paper goods	273,838	9,858,155	443,809	1,013,718	1,731,364	739,690
Books, maps, diaries	81,255	2,925,173	131,690	300,797	513,741	219,485
Newspapers	329,067	9,009,038	405,582	926,403	1,661,052	675,978
Magazines and periodicals	30,205	826,934	37,228	85,034	152,467	62,048
Paper packaging	150,282	2,685,939	120,920	276,196	547,397	201,535
Toilet Paper	115,796	1,910,634	86,016	196,471	398,283	143,361
Commercial Services	2,140,125	58,591,285	2,637,749	6,024,963	10,802,838	4,396,299
Public administration	414,893	11,358,731	511,364	1,168,022	2,094,280	852,283
Total	3,535,461	97,165,889	4,374,358	9,991,604	17,901,423	7,290,681

In 2000, the South East consumed over 3.5 million tonnes of paper. The majority of this paper ended up in the waste stream (landfill) while the remainder was either burnt or stored in households (particularly books). To provide 3.5 million tonnes of paper required over 4 million tonnes of fuel (based on the methodology described in Chapter 2). In total, almost 18 million tonnes of materials were required to provide 3.5 million tonnes of paper. The consumption of paper was responsible for 7.3 million tonnes of greenhouse gas emissions. Most of the paper consumption can be attributed to the commercial services sector (60 per cent of total consumption or 2.1 Mt of 3.5 Mt).

Consumption within commercial services has been broken down by percentage (see Figure 3.6).

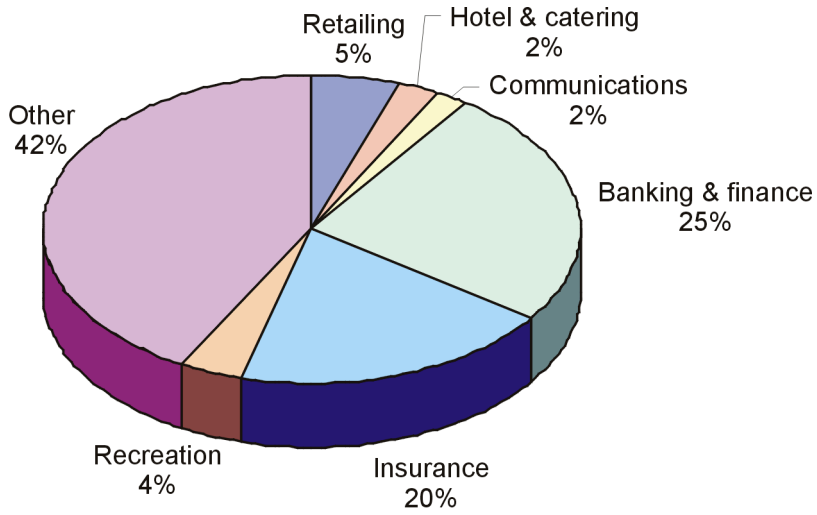

Figure 3.6 Paper consumption (2000) within the commercial sector of South East England (percentage)

Within the commercial sector, a large proportion of paper consumption could not be allocated to a particular sector (category "Other" in Figure 3.6). However, the banking and finance industry were responsible for a considerable percentage (25 per cent). Table 3.6.2 describes the flow of paper through the South East.

Table 3.6.2 Mass balance data for paper consumption in the South East (all figures in tonnes)

Input		Added to Storage	Output	
Paper product	3,535,461	56,543	3,478,918	Waste[59]
Energy Carriers	4,374,358		7,290,681	GWP[60]
Hidden Flows	9,991,604		9,991,604	Hidden Flows
Total	17,901,423		20,645,407	Total

A very small proportion of paper is retained in the economy (under 2 per cent). According to PRODCOM the total paper consumption in the UK for 2002 was 14 million tonnes. This figure is relatively close to the calculation from the British Federation of Paper Manufacturers (approximately 13 million tonnes).

The South East is responsible for the consumption of 3.5 Mt or approximately 25 per cent of the total UK paper consumption. This means that – on a per capita basis – South East residents consume paper at a 50 per cent higher rate than the national average. Therefore, a greater proportion of paper will appear in the domestic and commercial waste stream.

In terms of the ecological footprint, land is required to both grow the necessary timber for paper production and notional energy land to sequester the energy requirements of production. The footprint calculation results are presented in the table below.

Table 3.6.3 Ecological footprint of paper consumption in the South East (all numbers in global hectares)

Category	Energy Footprint (gha)	Land Footprint (gha)	Total Footprint (gha)
Greetings cards, stationery and paper goods	191,364	306,990	498,354
Books, maps, diaries	56,783	91,092	147,875
Newspapers	174,881	368,906	543,787
Magazines and periodicals	16,052	33,862	49,914
Paper packaging…	105,020	83,642	188,662
Toilet Paper	37,089	129,815	166,904
Commercial Services (All paper)	1896,793	3,234,909	5,131,702
Public administration (All paper)	367,719	627,132	994,851
Total	2,845,701	4,876,348	7,722,049

In terms of paper consumption and the ecological footprint, commercial services has, by far, the most significant impact. In terms of households, newspapers are the most significant component of paper consumption. The tonnage of paper consumed by commercial services was cross-checked with the commercial waste stream. As paper is generally a product that passes through the economy quickly, the waste stream, in this case, is a good indicator of consumption.

[59] It is assumed that the 115,796 tonnes of toilet paper is disposed of via the sewage system.

[60] Within a "Mass Balance Analysis" there should be a balance between the inputs to the system and the outputs. However, the "Energy carriers" inputs do not add up with the outputs (i.e. Greenhouse Gas Emissions). This can be explained by the input of oxygen within the combustion process (i.e. the difference between carbon and carbon dioxide). The actual weight of carbon released from the energy carriers is approximately 2 million tonnes.

3.6.4 Textiles, clothing and footwear

A range of different materials are used to provide clothing and other textiles. As well as understanding the consumption of the products, a detailed material composition of various categories has been undertaken. Three broad categories were selected that correspond with the Household Expenditure Survey, these being clothing, ties and other accessories and footwear.

Table 3.6.4 Material Flow Analysis of the consumption of textiles and footwear in the South East

Category	Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total Material Requirement (tonnes)	GWP (tonnes $C0_2$ equivalent)
Clothing						
...Cotton	34,948	3,013,429	105,274	313,002	453,224	226,108
...Polyacryl	1,028	137,070	3,804	5,858	10,690	10,285
...Polyamide	3,084	128,366	3,563	5,486	12,132	9,632
...Polyester	6,681	971,241	26,956	41,505	75,143	72,875
...Viscose	2,570	154,184	4,279	6,589	13,438	11,569
...Wool	3,084	217,297	7,591	22,570	33,245	16,305
Ties, belts, hats, gloves, etc						
...Silk	84	5,034	140	215	439	378
...Cotton	252	21,703	758	2,254	3,264	1,628
...Wool	294	20,693	723	2,149	3,166	1,553
...Leather	210	5,915	207	614	1,031	444
Footwear						
...Leather	17,160	483,912	16,905	50,263	84,329	36,310
...Rubber	8,580	579,150	16,074	24,749	49,403	43,456
...Plastic	2,860	119,055	3,304	5,088	11,252	8,933
Textile Consumption by the Commercial Sector	103,758	11,060,190	386,386	667,177	1,157,321	829,883
Textile Consumption by Public Administration	21,292	2,269,623	79,289	235,743	336,324	170,297
Total	205,885	19,186,862	655,253	1,383,262	2,244,401	1,439,656

PRODCOM was employed as the basic database to derive the total tonnes of clothing materials consumed by UK households. As previously mentioned, there are a considerable number of disparities within the PRODCOM database. For example, using PRODCOM figures we would have suggested that only 0.05% of the UK population buy a new pair of shoes every year. Even using the data from earlier years would give a similarly inaccurate answer.

Our approach has been to ensure that all the figures are cross-checked with a number of references. To overcome the particular problem associated with shoes, the British Footwear Association was contacted and they provided accurate data on sales of various types of shoes. To understand the material composition of clothes, in order to calculate the embodied energy, results from a Dutch study were applied and cross-checked with PRODCOM[61].

[61] Noormand and Uiterkamp (1998) *Green Households? – Domestic Consumers, Environment and Sustainability*, Earthscan.

The ecological footprint of clothing considers both the notional energy land and the land area required to grow cotton and other bio-materials.

Table 3.6.5 Ecological Footprint of textile and footwear consumption in the South East (all numbers in global hectares)

Category	Energy Footprint (gha)	Land Footprint (gha)	Total Footprint (gha)
Clothing	89,713	38,126	127,838
Ties, belts, hats, gloves	1,036	275	1,310
Footwear	26,132	18,720	44,852
Commercial Services (Textiles)	214,697		214,697
Public Administration (Textiles)	44,057		44,057
Total	375635	57121	432,756

As with the previous section concerning paper, it is commercial services who are the highest consumers and have the highest impact. It was not possible to break this figure down into particular product types. For households, cotton consumption through clothing has the most significant impact.

3.6.5 Packaging

South East residents consumed nearly 0.9 million tonnes of packaging in 2000. This equates to 100 kg of packaging per person. The majority of this packaging (74 per cent) is for food products. To establish the total tonnage of packaging consumed by South East residents, a detailed investigation of the domestic waste stream was undertaken as well as applying recent studies from the Industry Council for Packaging and the Environment (INCPEN[62]). EcoSys provided a detailed domestic waste composition (see Table 3.6.5). Employing the analysis suggested by INCPEN the total tonnage of packaging was derived. INCPEN have established the tonnage of various materials that appear in the waste stream that are packaging (see Table 3.6.6). For example, only 13 per cent of all paper that appears in the domestic waste stream is packaging. However, 96 per cent of all aluminium in the domestic waste stream is packaging.

Table 3.6.6 Total tonnage of household packaging in the South East

Material	Tonnage in Domestic Waste Stream	Percentage of Waste Stream that is Packaging	Total Tonnage of Household Packaging
Paper	1,156,014	13 %	150,282
Glass	347,859	84 %	292,202
Aluminium	38,507	96 %	36,967
Steel	197,111	78 %	153,746
Plastic	357,863	71 %	254,083
Total	2,097,354		887,280

The data have been verified by conducting a comparison with another INCPEN study where they suggest the average household consumes 190 kg of packaging a year. This study suggests that the average South East household requires approximately 210 kg per year. Higher levels of resource consumption in the South East than other UK regions can explain the differential.

[62] The authors would like to thank Incpen for providing data beyond information that was published.

By weight, glass accounted for the largest amount of packaging within the domestic sector closely followed by plastics. However, glass containers packaged less items than the plastic due to the difference in weight of material required for each type. For example, SEI has conducted a study to establish the average packaging of various product types and packaging materials. For a 500 ml drink, the average weight of the glass bottle was 410 g compared to the PET bottle weighing a tenth of this (42 g).

Packaging is seen as an area where potentially, reductions in environmental impacts can be made. Packaging is a very visible example of environmental impact as individuals dispose of it themselves. In terms of environmental impact however, packaging has a considerably lower impact than the production of food or consumer items that it is protecting. Table 3.6.7 indicates the material flow of packaging within the South East.

Table 3.6.7 Material Flow Analysis of household packaging materials in the South East

Category	Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total Material Requirement (tonnes)	GWP (tonnes $C0_2$ equivalent)
Paper	**150,282**	**5,410,145**	**243,562**	**556,327**	**950,171**	**405,941**
Glass	**292,202**	**10,519,268**	**348,577**	**776,554**	**1,417,333**	**789,296**
Aluminium	**36,967**	**1,330,817**	**54,794**	**228,993**	**320,754**	**99,856**
Steel	**153,746**	**5,534,865**	**250,553**	**920,446**	**1,324,746**	**415,299**
Plastic	**254,083**	**9,146,982**	**253,869**	**390,887**	**898,839**	**686,329**
Total	**887,280**	**31,942,076**	**1,151,356**	**2,873,207**	**4,911,842**	**2,396,720**

According to INCPEN, the average person requires 7 GJ to provide the 190 kg of packaging per year. In this study, it has been calculated that 4 GJ is required per South East resident, suggesting a slightly conservative figure. However, there are large disparities in embodied energy data that could explain the difference. In terms of the total material requirement of packaging, to provide 0.8 million tonnes of packaging, nearly 5 million tonnes of materials are required. In terms of greenhouse gas emissions, 2.4 million tonnes are produced (0.3 tonnes per person). This figure is based on an analysis of the fuel consumption of European industries, broken down into the various economic sectors (see Chapter 2 for more details).

In terms of the impact of packaging materials, glass is still the most significant due to its weight, although the impacts of paper and plastics are also significant. In terms of the ecological footprint, paper has a more significant impact than plastic because of the land area required to provide timber.

Table 3.6.8 Ecological Footprint of household packaging materials in the South East (all numbers in global hectares)

Category	Energy Footprint	Land Footprint	Total Footprint
Paper	**105,020**	**83,642**	**188,662**
Glass	**204,197**		**204,197**
Aluminium	**25,833**		**25,833**
Steel	**107,441**		**107,441**
Plastic	**177,559**		**177,559**
Total	**620,050**	**83,642**	**703,692**

Comparing the impact of packaging with other consumption items such as food and household consumables demonstrates that the impact of packaging items is minimal by comparison (Food 3.8 tonnes of GHG, Household 1.5 tonnes and Packaging 0.3 tonnes). The fact that the impact of packaging is considerably lower than that of household products and food does not mean that improvements in environmental performance of packaging cannot be made. For example, the majority of packaging items can be recycled with significant benefits (see Chapter 4). Moreover, excessive packaging of products to promote a particular product is a growing phenomenon. There is also the possibility of promoting home delivery of key products to reduce the requirement for packaging (e.g. a milk home delivery service[63]).

Packaging has been associated with particular product categories in Table 3.6.9 below. This methodology was devised by SEI in a study of York (A Material Flow Analysis and Ecological Footprint of York, www.yorkfootprint.org).

Table 3.6.9 Material composition of packaging for different product categories

Category	Tonnes
Food and Drink	***659,132***
...Paper	71,563
...Glass	272,722
...Aluminium	28,195
...Steel	117,264
...Plastic	169,389
Electrical equipment	***5,058***
...Paper	4,110
...Glass	
...Aluminium	
...Steel	
...Plastic	948
Household Consumables	***223,089***
...Paper	74,609
...Glass	19,480
...Aluminium	8,772
...Steel	36,482
...Plastic	83,746
Total	**887,280**

The majority of packaging can be associated with food and drink (particularly glass, steel and aluminium products). Other household consumables include shampoo bottles and containers for cleaning liquids etc. The majority of this packaging is plastic. A summary of the mass balance for household packaging in the South East is given in Table 3.6.10.

[63] For more information on milk delivery compared with purchasing milk from a supermarket, a recent Ecological Footprint has been undertaken by Louise Hare entitled "Assessing Product Sustainability, A Case Study of Chester using Ecological Footprints". Please contact the authors of this study for further details.

Table 3.6.10 Mass balance data for household packaging in the South East (all figures in tonnes)

Input		Output	
Product	**887,280**	**887,280**	**Waste**
Energy Carriers	**1,151,356**	**2,396,720**	**GWP[64]**
Hidden Flows	**2,873,207**	**2,873,207**	**Hidden Flows**
Total	**4,912,023**	**6,157,207**	**Total**

3.6.6 Miscellaneous items

Using the PRODCOM database a number of other products were considered and assumptions taken about the proportion of these items consumed by South East residents. These ranged from pet food, to nappies and toiletries.

Table 3.6.11 Material Flow Analysis of the consumption of other consumable items in the South East

Category	Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total Material Requirement (tonnes)	GWP (tonnes CO_2 equivalent)
Tobacco	**7,916**	**316,637**	**10,717**	**28,492**	**47,125**	**23,758**
Detergents, washing-up liquid, washing powder	**93,694**	**281,206**	**7,805**	**218,347**	**319,846**	**281,206**
Disinfectants, polishes, other cleaning materials	**90,090**	**270,390**	**7,505**	**209,949**	**307,544**	**270,390**
Pet food	**228,484**	**18,278,707**	**618,638**	**1,644,794**	**2,491,917**	**1,371,512**
Pet care	**2,075**	**62,534**	**2,831**	**10,399**	**15,305**	**4,692**
Leather & travel goods	**29,029**	**818,611**	**28,598**	**85,028**	**142,655**	**61,423**
Personal effects e.g. jewellery	**3,110**				**3,110**	
Baby toiletries and disposables	**33,977**	**2,929,650**	**102,347**	**107,971**	**244,295**	**219,821**
Baby equipment	**14,660**	**441,797**	**19,999**	**73,471**	**108,130**	**33,149**
NHS prescriptions	**2,221**				**2,221**	
Non NHS: medicines,	**9,624**	**829,807**	**28,989**	**86,191**	**124,804**	**62,263**
Spectacles, lenses, prescription sunglasses	**1,555**	**25,177**	**834**	**1,859**	**4,247**	**1,889**
Accessories: e.g. contact lens cleaning fluid incl. non-prescription sunglasses	**111**	**1,798**	**60**	**133**	**303**	**135**
Toiletries - cotton wool, toothpaste, shaving soap and brushes	**8,237**	**710,218**	**24,811**	**26,175**	**59,223**	**53,290**
Toilet soap	**27,456**	**82,405**	**2,287**	**63,985**	**93,728**	**82,405**
Other toilet requisites e.g. razors, toothbrushes	**19,779**	**1,332,585**	**36,985**	**56,947**	**113,711**	**99,988**

[64] Within a "Mass Balance Analysis" there should be a balance between the inputs to the system and the outputs. However, the "Energy carriers" inputs do not equal the outputs (i.e. Greenhouse Gas Emissions). This can be explained by the input of oxygen within the combustion process (i.e. the difference in molecular weight between carbon and carbon dioxide).

Category	Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total Material Requirement (tonnes)	GWP (tonnes CO_2 equivalent)
Hair products - shampoo, colour rinses	**16,782**	**50,369**	**1,398**	**39,110**	**57,291**	**50,369**
Cosmetics and related accessories including after shave, sun lotion	**7,192**	**21,587**	**599**	**16,762**	**24,553**	**21,587**
Photography	**319**	**9,621**	**436**	**1,600**	**2,355**	**722**
Horticultural goods	**19,452**	**175,071**	**6,613**	**636**	**26,701**	**13,997**
Total	615,763	26,638,170	901,452	2,671,849	4,189,064	2,652,596

Of all these categories, three have a particularly significant impact: pet food, nappies and cleaning materials (detergents, disinfectants, soaps etc.). Collectively, these three items have a considerable impact of 2.6 million tonnes of GHG emissions, representing 0.3 tonnes per capita. The ecological footprint of these three items are listed below (Table 3.6.12).

Table 3.6.12 Ecological Footprint of the consumption of other consumable items in the South East (all numbers in global hectares)

Category	Energy Footprint (gha)	Land Footprint (gha)	Total Footprint (gha)
Total	**686,248**	**404,299**	1,090,547
…of which			
Cleaning materials	**142,702**		**142,702**
Pet food	**354,821**	**292,049**	**646,870**
Nappies	**58,869**		**58,869**

3.6.7 Conclusions

The total GHG emissions to produce the consumable items are nearly 1,238 million tonnes. This equates to 1.7 tonnes per South East resident. As most of these products are produced outside of the South East region they would not normally be included within an analysis of GHG emissions. In summary, the most significant impact is due to paper consumption (0.9 tonnes per person). This represents a considerable impact in terms of the flow of materials, the greenhouse gas emissions and the ecological footprint. The commercial sector in particular consumes a significantly large amount of paper.

Collectively, the range of smaller products causes the remainder of the impact (0.8 tonnes of GHG emissions per person).

3.7 Durable Products

In this section results from MFA and EF calculations for cars, electrical equipment, furniture and soft furnishing are presented.

3.7.1 Material Flow Analysis of passenger cars

This section considers the material use associated with the production of passenger cars bought by South East residents in 2000. The material use of infrastructure and the fuel used by cars is included under the passenger transport section. This also includes the energy carriers associated with car manufacturing and maintenance. Therefore, Ecological Footprint calculations are not included in this section but in Chapter 3.2.

Passenger cars have the greatest share in the total number of vehicles, followed by delivery vans and trucks. When expressed in terms of the materials contained in vehicles, passenger cars (1100 kg/car) is still the most important category. Households of the South East own 16 per cent of all the cars in the UK while only having 13.5 per cent of the population. Moreover, over 34 per cent of households own two cars or more, higher than any other region (ONS 2002)[65]. The number of new cars purchased in the South East in 2000, on a per capita basis, was also higher than any other region. This equated to 373,200 new cars of which 10 per cent were company cars.

In the absence of a detailed breakdown of the type of cars that were bought in the South East, it is assumed that material composition and weight of the cars are the average for the UK. In 2000, the average new car within the UK weighed 1.113 tonnes (Bouwman and Moll 1997)[66]. This adds up to a total weight of 415,372 tonnes of new cars in the South East. Table 3.7.1 highlights the material composition of these cars as well as the hidden flows of the materials.

Table 3.7.1 Material Flow Analysis of cars bought in the South East in 2000 (all numbers in tonnes)

Material breakdown of cars	Amount of Materials	Hidden Flows	Waste in Production	Total Material Flow
Galvanised sheet steel	69,788	280,270	1,117	350,059
Cold rolled coil steel	58,592	235,307	937	293,899
Hot rolled coil steel	41,798	167,862	669	209,661
Heavy plate steel	1,120	4,496	18	5,616
Alloy steel	66,430	266,781	1,063	333,211
Wire rod	2,612	1,173,020	52	1,175,632
Cast iron	7,091	29,044	681	36,135
Cast aluminium	35,454	525,322	603	560,776
Wrought aluminium	12,689	188,010	216	200,699
Copper	5,225	2,346,040	104	2,351,264
PE	2,239	107	72	2,347
PP	15,301	734	490	16,036
PVC	6,344	305	203	6,649
Other thermoplastics	16,794	806	537	17,600
Thermosets	7,091	340	227	7,431
Synthetic rubber	20,526	10,756	493	31,282
Glass	12,316	4,729	296	17,045

[65] Office for National Statistics (2002) Family Spending, Expenditure and Food Survey

[66] Bouwman ME and Moll HC (1997) Status quo and expectations concerning the material composition of road vehicles and consequences for energy use. IVEM Report OR-91, IVEM, Groningen, NL

Material breakdown of cars	Amount of Materials	Hidden Flows	Waste in Production	Total Material Flow
Other material	33,961	13,041	815	47,002
Total	415,372	5,246,971	8,591	5,662,343

For every car that is manufactured, 14 tonnes of waste materials are produced either through the excavation of materials or waste produced during the production process. While most of the waste materials within the production are re-melted, such as steel, the system is not completely closed. On average over 2% of the materials cannot be re-used or recycled within the production process and therefore enter the waste stream.

In 2000, 415,372 tonnes of new cars entered the South East while only 301,400 tonnes were disposed of (Table 3.7.2). This increased the stock of cars by nearly 100,000 tonnes. Of the 301,400 tonnes that entered the waste stream, the majority of this was recycled (54%). The materials that are recycled are the ferrous and non-ferrous metals, leaving the higher composite thermoplastics that are disposed of by landfill. Also, it is not possible to recover all the metal components. Therefore, 146,448 tonnes of car waste were disposed of by landfill and 174,096 tonnes were recycled.

Table 3.7.2 Mass balance data for new cars in the South East in 2000 (all numbers in tonnes)

Material Input	Stock	Material Output
415,372	4,345,375	301,400

As well as the manufacture of the car, continual maintenance is required during its lifespan. Information concerning the materials used in maintenance is scarce. Therefore, an insight into the processes of maintenance is required. Some materials are required to be replaced on a regular basis - such as tyres. Moreover, in a yearly service the oil is replaced. Moll and Kramer (1996)[67] in their study of car maintenance have employed two replacements rates for different car parts. It is assumed that the maintenance level for materials that are replaced often is 3.3 per cent of the total material use per car in a year (oil and rubber). For all other categories, an annual maintenance of 1.12 per cent is used. These figures have been applied to this study. Therefore, in the South East, nearly a 100,000 tonnes of materials are bought for the sole purpose of maintaining road vehicles. This figure includes company- as well as privately-owned cars. The breakdown of these materials is shown in Table 3.7.3 along with the subsequent hidden flows.

[67] Moll HC, Kramer KJ (1996) Naar een optimale levensduur van de personenauto. Technische factfinding in het kader van het project "Levensduurverlenging Personenauto's". IVEM, Groningen, NL

Table 3.7.3 Flow analysis of materials to maintain road vehicles in the South East (all numbers in tonnes)

Total Weight of Materials	92,638 tonnes		
	Tonnes	Hidden Flow	Total
Galvanised sheet steel	8,177	32,708	40,885
Cold rolled coil steel	6,865	27,461	34,326
Hot rolled coil steel	4,897	19,950	24,487
Heavy plate steel	131	525	656
Alloy steel	7,783	31,134	38,917
Wire rod	306	137,434	137,740
Cast iron	831	3,323	4,154
Cast aluminium	4,154	61,480	65,634
Wrought aluminium	1,487	22,003	23,490
Copper	612	274,868	275,480
PE	262	4	267
PP	1,793	29	1,821
PVC	743	12	755
Other thermoplastics	1,968	31	1,999
Thermosets	831	13	844
Synthetic rubber	7,086	3,534	10,629
Glass	4,252	1,531	5,782
Other material	11,724	4,221	15,945
Oil	28,735	460	29,195
Total	92,638	620,369	713,007

3.7.2 Electrical equipment

The diagram below demonstrates the rate of growth in ownership of appliances during the last 30 years. In 1970, fridge-freezers, dish-washers, tumble-dryers and microwaves were not widely available and freezers were considered a luxury item. However, in the UK in 2000 there were 15 million fridge-freezers, 6 million dish-washers, 8 million tumble-dryers, 20 million microwaves and 10 million freezers.

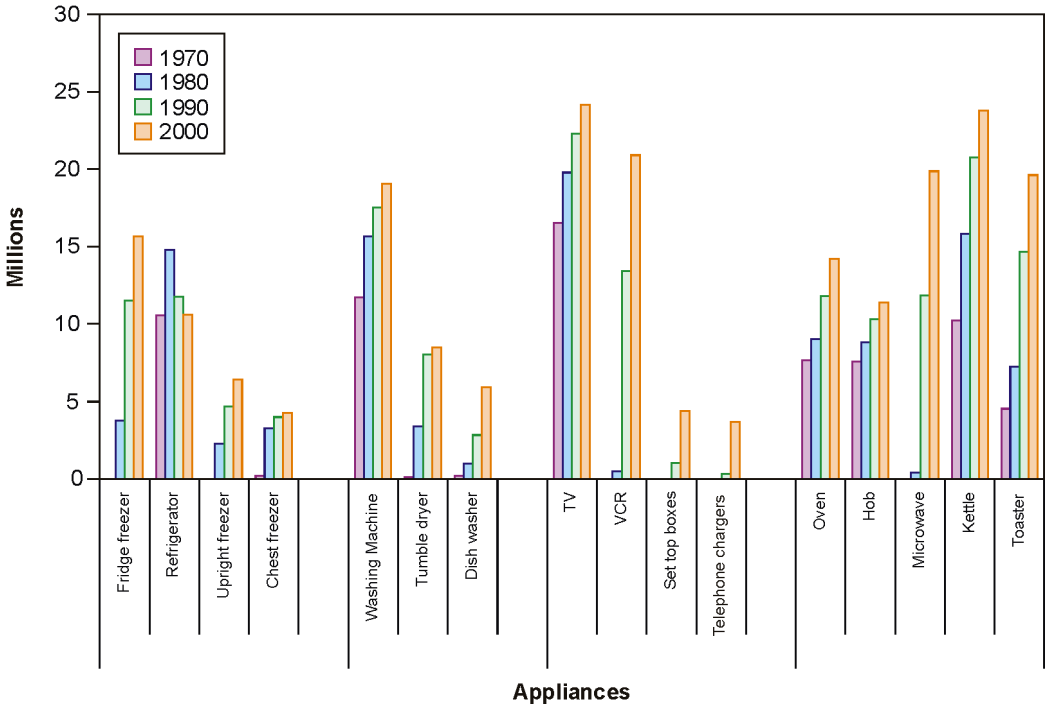

Figure 3.7 Number of appliances owned by households in the UK, 1970-2000

Households in the South East spend more on electrical equipment than any other region in the UK. The average household in the South East spends £62.40 a year on electrical equipment. This translates to a market of £212.6 million.

Material Flow Analysis for electrical items

The environmental impact of all electrical equipment is quantified in terms of the material flows including hidden flows, the CO_2 emissions and the Ecological Footprint. The MFA includes the energy carrier equivalent of the embodied energy of the items as input and the associated GHG emissions as output.

To establish an MFA of electrical equipment, a number of assumptions have been made on sales, material composition and embodied energies of electrical goods.

Sales numbers have been derived from UK retail sales given in the ICER Report (Industry Council for Electronic Equipment Recycling, 2000, UK Status Report on Waste from Electrical and Electronic Equipment, London). This report includes data on sales of electrical equipment to households and to the commercial sector in the UK. A proxy methodology has been applied in order to derive sale rates for the South East. For the commercial sector an average of 15.6 % has been adopted whereas in the domestic sector various proxy figures have been applied depending on the kind of electrical equipment (see Tables 3.7.4 and 3.7.5).

Table 3.7.4 Number of households (HH) with selected durable goods

	SE HH [%]	UK HH [%]	Number of SE HH	Number of UK HH	Proportion SE/UK (proxy)[1)]
Microwave oven	78	78	2,579,460	19,266,780	13.4%
Washing machine	91	91	3,009,370	22,477,910	13.4%
Tumble drier	57	50	1,884,990	12,350,500	15.3%
Dishwasher	31	23	1,025,170	5,681,230	18.0%
Deep or fridge freezer	93	92	3,075,510	22,724,920	13.5%
Telephone	97	95	3,207,790	23,465,950	13.7%
Video	86	84	2,844,020	20,748,840	13.7%
Compact disc player	73	66	2,414,110	16,302,660	14.8%
Satellite dish	27	28	892,890	6,916,280	12.9%
Home computer	40	31	1,322,800	7,657,310	17.3%

Source: Region in Figures - South East, Office for National Statistics, 2001

1) Example for interpretation: 18 % of all UK households that own a dishwasher are located in the South East

Table 3.7.5 Number of business sites in the UK and the South East

	SE	UK	Proportion SE/UK (proxy)[1)]
Distribution, hotels and catering repairs	77,094	550,758	14.0%
Transport and communication	11,745	82,806	14.2%
Finance, real estate renting and business activities	98,174	512,243	19.2%
Education and health	19,575	134,801	14.5%
Public administration and other services	31,319	192,573	16.3%
Total Business Sites	301,148	1,925,726	15.6%

Source: Office of National Statistics (2002) Classification of Business Sites by Subregion, Inter-Departmental Business Register.

1) The average of 15.6 % was adopted for all kinds of electrical equipment

Using these proxies, retail sales (i.e. consumption) of electrical equipment in the South East have been calculated. The results (in tonnes) are shown in Table 3.7.6 together with the average material composition of the electrical items in percentages.

Table 3.7.6 Sales of electrical equipment in the South East and material composition

Electrical Item	SE sales to HH [tonnes]	SE sales to commercial sector [tonnes]	Ferrous Metals	NF Metals	Glass	Plastics	Paint (guess)	Other
Large Appliances	***59,066***	***21,355***						
Refrigerators	9,563	4,736	60%	6%	2%	18%	0.5%	13.5%
Fridge-freezers	4,590	589	60%	6%	2%	18%	0.5%	13.5%
Freezers (chest, box)	2,129	2,460	60%	6%	2%	18%	0.5%	13.5%
Washing machines	22,368	6,532	50%	10%	2%	5%	0.5%	32.5%
Clothes dryers	4,500	512	88%	4%	0%	8%	0.5%	0.0%
Dishwashers	4,679	451	60%	3%	0%	11%	0.5%	25.5%
Cookers	5,454	708	89%	2%	6%	1%	0.5%	1.5%
Microwave ovens	5,456	4,249	65%	8%	6%	2%	0.5%	18.5%
Heating appliances	88	11	10%	3%	0%	7%	0.5%	79.5%
Air conditioners	240	1,107	0%	0%	0%	0%	0.0%	100.0%
Small Appliances	*5,047*	*840*						
Vacuum cleaners	2,146	614	1%	0%	0%	65%	0.5%	33.5%
Electric irons	543	-	44%	0%	0%	35%	0.5%	20.5%
Toasters	749	95	60%	4%	0%	10%	0.5%	25.5%
Fryers	305	-	0%	0%	0%	0%	0.0%	100.0%
Tea/coffee machines	65	32	2%	14%	0%	45%	0.5%	38.5%
Electrical knifes	55	-	0%	0%	0%	0%	0.5%	99.5%
Hair care	780	99	13%	0%	0%	48%	0.5%	38.5%
Electric toothbrushes	137	-	0%	0%	0%	0%	0.0%	100.0%
Electric shavers	268	-	0%	0%	0%	0%	0.0%	100.0%
IT Equipment	***8,247***	***78,540***						
Centralised data processing:								
Systems - small	-	3,691	33%	0%	0%	23%	0.5%	43.5%
Systems - medium	-	1,016	33%	0%	0%	23%	0.5%	43.5%
Systems - large	-	313	33%	0%	0%	23%	0.5%	43.5%
Workstations	-	660	33%	0%	0%	23%	0.5%	43.5%
LAN Hardware	-	28,633	50%	0%	0%	30%	0.5%	19.5%
Personal computing:								
Personal computers (office & home)	6,171	16,758	34%	0%	22%	27%	0.5%	16.5%
Copying equipment	-	23,082	50%	0%	0%	30%	0.5%	19.5%
Electrical typewriters	1,108	2,340	50%	0%	0%	30%	0.5%	19.5%
Calculators	969	2,046	22%	0%	0%	75%	0.5%	2.5%
Telecommunications	***1,222***	***1,056***						
Facsimiles	53	244	13%	7%	0%	74%	0.5%	5.5%
Telephones	627	479	13%	7%	0%	74%	0.5%	5.5%
Payphones	-	68	13%	7%	0%	74%	0.5%	5.5%
Cellular telephones (mobiles)	541	265	13%	7%	0%	74%	0.5%	5.5%
Radio/TV etc.	***16,534***	***3,758***						
Radio sets	1,291	152	50%	7%	0%	30%	0.5%	12.5%

Electrical Item	SE sales to HH [tonnes]	SE sales to commercial sector [tonnes]	Ferrous Metals	NF Metals	Glass	Plastics	Paint (guess)	Other
TV (Large)	9,950	2,838	2%	1%	53%	30%	0.5%	13.5%
TV (Small)	756	96	8%	2%	43%	25%	0.5%	21.5%
Video cameras	111	-	70%	7%	3%	17%	0.5%	2.5%
Video recorders	2,112	602	20%	0%	0%	45%	0.5%	34.5%
Audio separates	155	70	38%	0%	0%	37%	0.5%	24.5%
Audio systems	2,159	-	14%	2%	0%	24%	0.5%	59.5%
Gas Discharge Lamps	*169*	*1,889*						
Linear fluorescent	150	1,548	1%	2%	93%	0%	0.5%	3.5%
Compact fluorescent	17	179	1%	1%	40%	40%	0.5%	17.5%
High intensity discharge	1	161	10%	15%	64%	0%	0.5%	10.5%
Monitoring and Control	*718*	*1,232*						
Fire protection/detection	718	1,232	0%	0%	0%	0%	0.0%	100.0%
Toys	*1,755*	-						
Video games	1,330	-	0%	0%	0%	0%	0.0%	100.0%
Other electronic toys	425	-	0%	0%	0%	0%	0.0%	100.0%
Electrical and Electronic Tools	*5,558*	-						
Electric garden tools	910	-	0%	0%	0%	0%	0.0%	100.0%
Lawnmowers	4,101	-	0%	0%	0%	0%	0.0%	100.0%
Hand-held power tools	547	-	0%	0%	0%	0%	0.0%	100.0%
Total	98,315	108,668						.

Source: Derived from ICER (2000) UK Status Report on Waste from Electrical and Electronic Equipment, Industry Council for Electronic Equipment Recycling, London.

Notes to Table 3.7.6:

- **numbers in italic style are subtotals**
- **if the material composition was unknown a figure of 100 % of "other" materials was adopted**
- **it was assumed that "non-ferrous" (NF) metals consist of 50 % aluminium and 50 % copper**

The material breakdown per item as given in Table 3.7.6 has been used to calculate the flow of basic materials together with the associated hidden flows (HF). The result of these calculations, the HF factors used and the corresponding CN[68] codes of the basic materials are presented in Tables 3.7.7 and 3.7.8.

[68] Combined Nomenclature; see Chapter 2.2

Table 3.7.7 Material flow analysis of electrical equipment consumed by South East households: Breakdown by basic materials and their hidden flows

CN 2-digit code	Material	Material consumption [tonnes]	Hidden flow factor[69]	Material consumption + hidden flows [tonnes]
76	Aluminium	3,350	15.6	52,254
74	Copper	1,117	450	502,447
70	Glass	8,535	1.36	11,607
32	Paint	447	1	447
39	Plastics	15,876	1.02	16,194
72	Steel	41,734	5.2	217,016
Other	Other	27,258	1	27,258
	Total	98,315		827,223

Table 3.7.8 Material flow analysis of electrical equipment consumed by the commercial sector in the South East: Breakdown by basic materials and their hidden flows

CN 2-digit code	Material	Material consumption [tonnes]	Hidden flow factor[69]	Material consumption + hidden flows [tonnes]
76	Aluminium	1,266	15.6	19,757
74	Copper	422	450	189,972
70	Glass	7,430	1.36	10,105
32	Paint	532	1	532
39	Plastics	28,032	1.02	28,593
72	Steel	47,635	5.2	247,705
Other	Other	23,349	1	23,349
	Total	108,668		520,013

The following two tables show the results of the total MFA broken down by item including energy carriers as well as hidden flows of both materials and energy carriers. The embodied energy of electrical items was calculated by adding the embodied energies of the materials they are made of. Energy values (in GJ) were converted into energy carriers (in tonnes) by using EU electricity generation conversion factors for the industry sector "Machinery" (incl. electrical appliances)[70]. Accordingly, the emissions of greenhouse gases during production were calculated by adding the embodied GHG emissions of the materials, other inputs and the production process itself. An example of these calculations for a washing machine is given in Table 3.7.10 in the section "Ecological Footprint of Electrical Items" further below.

[69] from Douglas I, Lawson N; School of Geography, The University of Manchester (2001) "The Human Dimensions of Geomorphological Work in Britain", *Journal of Industrial Ecology*, 4(2): 9-33

[70] Data for 1999 from IEA statistics and balances, 2001 edition. Conversion factor for energy carriers = 0.0367 t/GJ; conversion factor for hidden flows of energy carriers = 0.1256 t/GJ

Table 3.7.9 Material flow analysis of electrical equipment consumed by South East households: Total material flow including energy carriers; breakdown by electrical items

CN 2-digit code	Electrical item	Total weight incl. hidden flows [tonnes]	Energy carriers (EC) [tonnes]	Hidden flows of EC [tonnes]	Total MF input [tonnes]	GHG emissions as MF output [tonnes CO2 eq.]
	Large Appliances					
84	Refrigerators	104,450	50,775	173,696	328,922	185,047
84	Fridge-freezers	50,131	17,530	59,968	127,628	61,526
84	Freezers (chest, box)	23,253	7,864	26,902	58,019	27,322
84	Washing machines	345,103	65,005	222,377	632,485	233,399
84	Clothes dryers	43,315	23,234	79,483	146,032	85,339
84	Dishwashers	33,771	9,883	33,809	77,463	32,967
85	Cookers	39,395	17,869	61,129	118,393	67,619
85	Microwave ovens	74,250	24,594	84,133	182,976	93,504
84	Heating appliances	452	133	454	1,039	836
84	Air conditioners	240	600	2,054	2,894	3,778
	Small Appliances	-	-	-	-	
85	Vaccuum cleaners	2,264	17,856	61,082	81,202	181,992
85	Electric irons	1,550	3,330	11,393	16,273	11,253
85	Toasters	6,333	2,299	7,865	16,498	7,769
85	Fryers	305	11,460	39,205	50,971	43,572
85	Tea/coffee machines	1,186	1,095	3,744	6,025	3,534
85	Electrical knifes	55	168	574	796	567
85	Haircare	1,213	4,782	16,360	22,355	16,159
85	Electric toothbrushes	137	84	287	507	283
85	Electric shavers	268	328	1,124	1,720	1,110
	IT Equipment	-	-	-	-	
84	Centralised data processing:	-	-	-	-	
84	Systems - small	-	-	-	-	-
84	Systems - medium	-	-	-	-	-
84	Systems - large	-	-	-	-	-
84	Workstations	-	-	-	-	-
84	LAN Hardware	-	-	-	-	-
84	Personal computing:	-	-	-	-	
84	Personal computers (office & home)	15,504	31,765	108,664	155,933	114,030
84	Copying equipment	-	-	-	-	-
84	Electrical typewriters	3,442	3,169	10,842	17,453	9,774
84	Calculators	1,878	5,115	17,498	24,492	15,384
	Tele-communications	-	-	-	-	

CN 2-digit code	Electrical item	Total weight incl. hidden flows [tonnes]	Energy carriers (EC) [tonnes]	Hidden flows of EC [tonnes]	Total MF input [tonnes]	GHG emissions as MF output [tonnes CO2 eq.]
85	Facsimiles	543	283	969	1,795	1,032
85	Telephones	6,390	9,997	34,198	50,585	36,455
85	Payphones	-	-	-	-	-
85	Cellular telepones (mobiles)	5,507	8,615	29,472	43,595	31,417
	Radio/TV etc.	-	-	-	-	
85	Radio sets	15,148	6,794	23,242	45,184	22,019
85	TV (Large)	25,003	107,508	367,777	500,288	179,328
85	TV (Small)	2,992	30,323	103,734	137,049	50,580
85	Video cameras	1,400	3,269	11,184	15,853	5,646
85	Video recorders	3,905	74,441	254,656	333,002	128,551
85	Audio separates	403	814	2,785	4,002	2,639
85	Audio systems	8,759	1,893	6,476	17,128	6,135
	Gas Discharge Lamps	-	-	-	-	
85	Linear fluorescent	578	1,220	4,172	5,969	5,451
85	Compact fluorescent	42	68	234	344	376
85	High intensity discharge	29	12	39	80	52
	Monitoring and Control	-	-	-	-	
85	Fire protection/detecti on	718	1,164	3,983	5,864	5,203
	Toys	-	-	-	-	
85	Video games	1,330	78,106	267,195	346,630	134,880
85	Other electronic toys	425	24,986	85,475	110,886	43,148
	Electrical and Electronic Tools	-	-	-	-	
84	Electric garden tools	910	12,624	43,186	56,720	128,670
84	Lawnmowers	4,101	8,530	29,179	41,810	86,939
84	Hand-held power tools	547	2,275	7,781	10,603	23,184
	Total	827,223	671,860	2,298,379	3,797,461	2,088,468

Table 3.7.10 Material flow analysis of electrical equipment consumed by the commercial sector in the South East: Total material flow including energy carriers; breakdown by electrical items

CN 2-digit code	Electrical Item	Total weight incl. hidden flows [tonnes]	Energy Carriers (EC) [tonnes]	Hidden Flows of EC [tonnes]	Total MF Input [tonnes]	GHG emissions as MF output [tonnes CO2 eq.]
	Large Appliances					
84	Refrigerators	51,725	25,144	86,017	162,887	91,638
84	Fridge-freezers	6,436	2,251	7,699	16,386	7,899
84	Freezers (chest, box)	26,869	9,087	31,085	67,041	31,571
84	Washing machines	100,775	18,982	64,937	184,695	68,156
84	Clothes dryers	4,931	2,645	9,049	16,625	9,716
84	Dishwashers	3,252	952	3,256	7,459	3,174
85	Cookers	5,113	2,319	7,934	15,366	8,776
85	Microwave ovens	57,819	19,151	65,515	142,485	72,812
84	Heating appliances	58	17	58	133	107
84	Air conditioners	1,107	2,775	9,493	13,375	17,460
	Small Appliances	-	-	-	-	
85	Vacuum cleaners	648	5,107	17,469	23,223	52,049
85	Electric irons	-	-	-	-	-
85	Toasters	805	292	1,000	2,097	987
85	Fryers	-	-	-	-	-
85	Tea/coffee machines	582	537	1,836	2,954	1,733
85	Electrical knifes	-	-	-	-	-
85	Haircare	154	608	2,080	2,842	2,054
85	Electric toothbrushes	-	-	-	-	-
85	Electric shavers	-	-	-	-	-
	IT Equipment	-	-	-	-	
84	Centralised data processing:	-	-	-	-	
84	Systems – small	8,823	4,970	17,003	30,796	14,153
84	Systems – medium	2,430	2,111	7,220	11,761	6,860
84	Systems – large	748	665	2,274	3,687	2,152
84	Workstations	1,578	3,910	13,375	18,863	13,045
84	LAN Hardware	88,936	67,809	231,968	388,713	203,521
84	Personal computing:	-	-	-	-	
84	Personal computers (office & home)	42,106	86,264	295,103	423,474	309,677
84	Copying equipment	71,692	50,117	171,446	293,255	148,250
84	Electrical typewriters	7,269	6,695	22,902	36,865	20,645
84	Calculators	3,968	10,804	36,961	51,733	32,495
	Telecommunications	-	-	-	-	
85	Facsimiles	2,485	1,296	4,432	8,212	4,725
85	Telephones	4,874	7,624	26,081	38,579	27,802
85	Payphones	693	72	247	1,012	263
85	Cellular telephones (mobiles)	2,700	4,224	14,449	21,373	15,403
	Radio/TV etc.	-	-	-	-	
85	Radio sets	1,777	797	2,727	5,302	2,584
85	TV (Large)	7,131	30,664	104,899	142,694	51,149
85	TV (Small)	379	3,844	13,150	17,373	6,412
85	Video cameras	-	-	-	-	-

CN 2-digit code	Electrical Item	Total weight incl. hidden flows [tonnes]	Energy Carriers (EC) [tonnes]	Hidden Flows of EC [tonnes]	Total MF Input [tonnes]	GHG emissions as MF output [tonnes CO2 eq.]
85	Video recorders	1,114	21,232	72,634	94,980	36,666
85	Audio separates	182	368	1,261	1,811	1,194
85	Audio systems	-	-	-	-	-
	Gas Discharge Lamps	-	-	-	-	
85	Linear fluorescent	5,946	12,557	42,956	61,459	56,121
85	Compact fluorescent	435	703	2,406	3,545	3,876
85	High intensity discharge	3,241	1,306	4,467	9,015	5,837
	Monitoring and Control	-	-	-	-	
85	Fire protection/detection	1,232	1,998	6,834	10,063	8,928
	Total	520,013	409,897	1,402,223	2,332,132	1,339,890

Ecological Footprint of electrical items

The Ecological Footprint of electrical equipment has been calculated by taking into account the input, the stock and the output of electrical appliances in the South East as well as the embodied greenhouse gas emissions of their production.

In order to calculate input, stock and output of electrical equipment, data from the ICER report[71], as well as numbers of households with selected durable goods[72], were used. Again the proxy methodology for the South East was applied as described above (see Tables 3.7.9 and 3.7.10). With respect to outputs, the assumption was made that the proportional share between household and commercial consumption is the same for the production of waste.

Greenhouse gas emissions were derived from embodied energy data, other input and production data. An example of these calculations for a washing machine is given in Table 3.7.11. The calculations show that nearly a tonne of GHG emissions is emitted to produce the final product. Transport is not taken into account here but is included in the Freight Transport section (see Chapter 3.3), and neither is packaging and the land footprint.

When considering the ecological footprint of a durable item the lifetime (or better 'replacement time') has to be accounted for. The ecological impact of the item's production is distributed over the time span of its use which reduces the ecological footprint per year substantially (example see Table 3.7.11). Information obtained from the Association of Home Appliance Manufacturers provided the average useful life of major home appliances.

Table 3.7.11 Example for the calculation of embodied energy and emissions of the production of a washing machine

[71] UK Status Report on Waste from Electrical and Electronic Equipment, Industry Council for Electronic Equipment Recycling, 2000, London

[72] Region in Figures - South East, Office for National Statistics, 2001

	Weight [kg]	% of weight	Embodied energy [MJ/kg]	Embodied energy per item [MJ]	CH_4 emissions [kg]	CO_2 emissions [kg]	N_2O emissions [kg]	Total GWP[1)] [kg CO_2 eq.]
Material components of a washing machine								
Steel	**42.5**	**50%**	**29.96**	**1,288**	**0.334**	**142.67**	**0.0036**	**150.8**
Aluminium	**7.7**	**9%**	**168.01**	**1,512**	**0.392**	**167.47**	**0.0042**	**177.0**
Glass	**1.7**	**2%**	**10.57**	**21**	**0.028**	**15.57**	**0.0020**	**16.8**
Plastics (polystyrene)	**4.3**	**5%**	**82.00**	**328**	**0.056**	**24.56**	**0.0068**	**27.8**
Copper	**0.9**	**1%**	**97.59**	**88**	**0.023**	**9.73**	**0.0003**	**10.3**
Paint	**0.4**	**0.5%**	**65.10**	**20**	**0.006**	**1.74**	**0.0005**	**2.0**
Other	**27.6**	**32.5%**		**-**	**-**	**-**	**-**	**-**
	85.00	**100%**		**3,257**	**1**	**362**	**0**	**384.7**
Packaging								
Cardboard (corrugated)	**1.30**		**17.86**		**0.006**	**1.93**	**0.0009**	**2.34**
Polystyrene (granules)	**0.30**		**96.05**		**0.005**	**2.16**	**0.0006**	**2.45**
Other Inputs								
Residual goods				**3,022**	**1.046**	**425.84**	**0.0390**	**459.9**
Capital goods				**84**	**0.044**	**16.56**	**0.0022**	**18.2**
Production				**368**	**0.046**	**23.20**	**-**	**24.2**
Total (excluding packaging, transport, waste and services)				**6,731**				**886.9**
EF over lifetime [gha]								**0.2295**
EF per year [gha/yr] (replacement time = 10 years)								**0.0230**

1) GWP = global warming potential

Sources:

ICER (2000) UK Status Report on Waste from Electrical and Electronic Equipment, Industry Council for Electronic Equipment Recycling, London

Alcorn J. A. (1998) Embodied Energy Coefficients of Building Materials, Centre for Building Performance Research, Wellington

IVEM (1999) Interfacultaire Vakgroep Energie en Milieukunde Energy Analysis Program, Research Report no.98, Groningen, March 1999

The ecological footprint does not consider solely the inputs of new materials into the system but the impact of the total stock over the life span of this stock. For example, the total stock of washing machines which is considered is the stock + the inputs – the outputs. This figure is then multiplied by the ecological footprint per washing machine that takes into account its average life span of 10 years. Tables 3.7.12 and 3.7.13 show the results of EF calculations of electrical and electronic equipment consumed by households and the commercial sector in the South East. The total ecological footprints are 669,713 and 512,379 hectares, respectively.

Table 3.7.12 Ecological footprint of electrical equipment in South East households

CN 2-digit code	Item	INPUT [tonnes]	STOCK [tonnes]	OUTPUT [tonnes]	EF per item per year [gha/item/yr]	Total EF per year (stock + input - output) [gha/yr]
		-	**-**	**-**		
	Large Appliances	**-**	**-**	**-**		
84	**Refrigerators**	**9,563**	**107,643**	**6,694**	**0.0175**	**55,325**
84	**Fridge-freezers**	**4,590**	**139,886**	**3,208**	**0.0208**	**48,994**
84	**Freezers (chest, box)**	**2,129**	**151,543**	**1,491**	**0.0216**	**50,529**
84	**Washing machines**	**22,368**	**255,796**	**15,659**	**0.0229**	**70,862**

CN 2-digit code	Item	INPUT [tonnes]	STOCK [tonnes]	OUTPUT [tonnes]	EF per item per year [gha/item/yr]	Total EF per year (stock + input - output) [gha/yr]
84	Clothes dryers	4,500	65,975	3,149	0.0172	33,031
84	Dishwashers	4,679	53,309	3,277	0.0079	8,311
85	Cookers	5,454	176,329	3,817	0.0133	38,058
85	Microwave ovens	5,456	64,487	3,820	0.0123	32,572
84	Heating appliances	88	8,317	44	0.0012	2,047
84	Air conditioners	240	4,990	120	0.0012	2,085
		-	-	-		
	Small Appliances	-	-	-		
85	Vacuum cleaners	2,146	11,823	1,503	0.0137	34,185
85	Electric irons	543	2,365	380	0.0005	1,355
85	Toasters	749	5,423	599	0.0005	1,495
85	Fryers	305	4,068	214	0.0123	17,073
85	Tea/coffee machines	65	2,365	45	0.0018	4,212
85	Electrical knifes	55	2,712	38	0.0005	732
85	Haircare	780	2,365	546	0.0005	1,394
85	Electric toothbrushes	137	1,356	82	0.0001	76
85	Electric shavers	268	1,687	161	0.0001	192
		-	-	-		
	IT Equipment	-	-	-		
84	Centralised data processing:	-	-	-		
84	Systems - small	-	-	-	0.0099	-
84	Systems - medium	-	-	-	0.0436	-
84	Systems - large	-	-	-	0.1780	-
84	Workstations	-	-	-	0.0102	-
84	LAN Hardware	-	-	-	0.0092	-
84	Personal computing:	-	-	-		
84	Personal computers (office & home)	6,171	26,456	3,085	0.0239	35,308
84	Copying equipment	-	-	-	0.0208	-
84	Electrical typewriters	1,108	13,228	792	0.0023	3,091
84	Calculators	969	1,323	678	0.0004	663
		-	-	-		
	Telecommunications	-	-	-		
85	Facsimiles	53	4,068	21	0.0050	6,847
85	Telephones	627	3,208	314	0.0050	17,644
85	Payphones	-	-	-	0.0050	-
85	Cellular telephones (mobiles)	541	1,687	270	0.0050	9,805
		-	-	-		
	Radio/TV etc.	-	-	-		
85	Radio sets	1,291	3,142	904	0.0004	1,557
85	TV (Large)	9,950	73,945	4,975	0.0121	36,797
85	TV (Small)	756	19,908	-	0.0121	35,786
85	Video cameras	111	5,688	22	0.0026	7,581
85	Video recorders	2,112	14,220	1,056	0.0079	24,055
85	Audio separates	155	2,414	31	0.0004	1,119
85	Audio systems	2,159	14,485	1,080	0.0004	1,144
		-	-	-		
	Gas Discharge Lamps	-	-	-		
85	Linear fluorescent	150	642	143	0.0004	1,217
85	Compact fluorescent	17	126	9	0.0001	151
85	High intensity discharge	1	473	1	0.0004	888
		-	-	-		
	Monitoring and Control	-	-	-		
85	Fire protection/detection	718	2,034	431	0.0004	871

CN 2-digit code	Item	INPUT [tonnes]	STOCK [tonnes]	OUTPUT [tonnes]	EF per item per year [gha/item/yr]	Total EF per year (stock + input - output) [gha/yr]
		-	-	-		
	Toys	-	-	-		
85	Video games	1,330	2,365	931	0.0026	7,252
85	Other electronic toys	425	1,687	213	0.0026	4,984
		-	-	-		
	Electrical and Electronic Tools	-	-	-		
84	Electric garden tools	910	7,094	632	0.0137	33,695
84	Lawnmowers	4,101	47,290	2,871	0.0137	33,264
84	Hand-held power tools	547	2,365	383	0.0014	3,467
		-	-	-		
	Total	98,315	1,310,281	63,687		669,713

For the commercial sector no data on the stock were available. Therefore the assumption was made that the stocks in households and the commercial sector follow the same ratio as the inputs for these sectors. This method however cannot be applied to CDP (centralised data processing) equipment as households do not own these items. Data on the stock of CDP in the commercial sector are therefore estimated by assuming that the STOCK/INPUT ratio for personal computers in households (which is 4.3) is also true for CDP in the commercial sector (i.e. the stock of CDP is 4.3 times as much as the input within one year).

Table 3.7.13 Ecological footprint of electrical equipment in the commercial sector in the South East

CN 2-digit code	Item	INPUT [tonnes]	STOCK [tonnes]	OUTPUT [tonnes]	EF per item per year [gha/item/yr]	Total EF per year (stock + input - output) [gha/yr]
		-	-	-		
	Large Appliances	-	-	-		
84	Refrigerators	4,736	53,306	3,315	0.0175	27,398
84	Fridge-freezers	589	17,960	412	0.0208	6,290
84	Freezers (chest, box)	2,460	175,109	1,723	0.0216	58,387
84	Washing machines	6,532	74,697	4,573	0.0229	20,693
84	Clothes dryers	512	7,511	359	0.0172	3,760
84	Dishwashers	451	5,133	316	0.0079	800
85	Cookers	708	22,885	495	0.0133	4,939
85	Microwave ovens	4,249	50,216	2,974	0.0123	25,364
84	Heating appliances	11	1,068	6	0.0012	263
84	Air conditioners	1,107	23,065	554	0.0012	9,636
		-	-	-		
	Small Appliances	-	-	-		
85	Vacuum cleaners	614	3,381	430	0.0137	9,777
85	Electric irons	-	-	-	0.0005	-
85	Toasters	95	689	76	0.0005	190
85	Fryers	-	-	-	0.0123	-
85	Tea/coffee machines	32	1,159	22	0.0018	2,065
85	Electrical knifes	-	-	-	0.0005	-
85	Haircare	99	301	69	0.0005	177
85	Electric toothbrushes	-	-	-	0.0001	-
85	Electric shavers	-	-	-	0.0001	-
		-	-	-		
	IT Equipment	-	-	-		

CN 2-digit code	Item	INPUT [tonnes]	STOCK [tonnes]	OUTPUT [tonnes]	EF per item per year [gha/item/yr]	Total EF per year (stock + input - output) [gha/yr]
84	Centralised data processing:	-	-	-		
84	Systems - small	3,691	15,823 [a)]	2,596	0.0099	1,678
84	Systems - medium	1,016	4,358 [a)]	704	0.0436	815
84	Systems - large	313	1,341 [a)]	156	0.1780	267
84	Workstations	660	2,829 [a)]	463	0.0102	1,548
84	LAN Hardware	28,633	122,763 [a)]	20,040	0.0092	24,154
84	Personal computing:	-	-	-		
84	Personal computers (office & home)	16,758	71,848	8,379	0.0239	95,887
84	Copying equipment	23,082	98,962	16,154	0.0208	21,994
84	Electrical typewriters	2,340	27,941	1,673	0.0023	6,529
84	Calculators	2,046	2,794	1,432	0.0004	1,400
		-	-	-		
	Telecommunications	-	-	-		
85	Facsimiles	244	18,613	98	0.0050	31,330
85	Telephones	479	2,446	239	0.0050	13,456
85	Payphones	68	348	28	0.0050	129
85	Cellular telephones (mobiles)	265	827	133	0.0050	4,807
		-	-	-		
	Radio/TV etc.	-	-	-		
85	Radio sets	152	369	106	0.0004	183
85	TV (Large)	2,838	21,091	1,419	0.0121	10,495
85	TV (Small)	96	2,524	38	0.0121	4,470
85	Video cameras	-	-	-	0.0026	-
85	Video recorders	602	4,056	301	0.0079	6,861
85	Audio separates	70	1,093	14	0.0004	507
85	Audio systems	-	-	-	0.0004	-
		-	-	-		
	Gas Discharge Lamps	-	-	-		
85	Linear fluorescent	1,548	6,605	1,471	0.0004	12,534
85	Compact fluorescent	179	1,302	90	0.0001	1,556
85	High intensity discharge	161	53,558	113	0.0004	100,545
		-	-	-		
	Monitoring and Control	-	-	-		
85	Fire protection/detection	1,232	3,490	739	0.0004	1,494
		-	-	-		
	Toys	-	-	-		
85	Video games	-	-	-	0.0026	-
85	Other electronic toys	-	-	-	0.0026	-
		-	-	-		
	Electrical and Electronic Tools	-	-	-		
84	Electric garden tools	-	-	-	0.0137	-
84	Lawnmowers	-	-	-	0.0137	-
84	Hand-held power tools	-	-	-	0.0014	-
		-	-	-		
	Total	108,668	901,460	71,709		512,379

a) rough estimate: stock = 4.3 x input (see text)

3.7.3 Furniture and soft furnishing

Furniture

The total tonnage of furniture bought in the South East in 2000 was over 340,000 tonnes[73]. The material composition of the furniture was established by evaluating research conducted by the Federation of European Furniture Manufacturers (UEA)[74]. This provided a detailed breakdown of the main 12 materials used by the furniture industry. The embodied energy of the materials has been calculated and converted into tonnes of fuel (energy carriers). Combined with the hidden flows of the energy carriers, the total material flow of furniture in the South East is over 1.7 million tonnes. To provide the South East with 340,000 tonnes of furniture, an extra 1.4 million tonnes is required.

Table 3.7.14 Material Flow Analysis of the consumption of furniture in the South East

Material	Total Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total MFA (tonnes)	GWP (tonnes)
Board Materials	**126,154**	**3,126,105**	**164,867**	**324,916**	**615,937**	234,562
Solid Timber	**53,726**	**1,442,546**	**76,078**	**149,933**	**279,737**	108,239
Metal (mainly steel)	**39,785**	**1,198,992**	**54,276**	**199,392**	**293,453**	89,964
Plastics (mainly PA)	**30,263**	**2,038,949**	**56,590**	**87,132**	**173,986**	152,989
Fabrics	**21,082**	**1,264,944**	**44,191**	**131,388**	**196,661**	94,913
Leather	**952**	**26,849**	**938**	**2,789**	**4,679**	2,015
Glass	**6,053**	**98,023**	**3,248**	**7,236**	**16,537**	7,355
Liquid Coating	**10,541**	**656,506**	**18,221**	**28,055**	**56,817**	49,260
Marble and Stone	**1,700**	**68**	**2**	**7**	**1,710**	11
Rubber	**2,040**	**137,716**	**3,822**	**5,885**	**11,748**	10,333
Glue	**5,441**	**338,842**	**9,404**	**14,480**	**29,325**	25,424
Other	**42,301**				**42,301**	
Total	**340,039**	**10,329,540**	**431,638**	**951,214**	**1,722,890**	**775,066**

In terms of GHG emissions the production of furniture for the South East is responsible for 775,000 tonnes of GHG emissions. Concerning the solid waste, a lot of furniture is moved around within the economy of the South East. Therefore, a lot of the furniture items are re-used by other residents in the South East. Schemes often set out to provide low cost furniture for individuals and households on low incomes. One such is example is Furniture Now in Brighton who have currently recycled over 400 tonnes of old furniture since first forming in 1997[75]. There are approximately another 45 similar businesses across the region.

The most significant materials consumed within furniture are the board materials (126,000 tonnes). In terms of greenhouse gas emissions a considerable proportion of plastic within furniture has a significant impact, representing only 9 per cent by weight, but 20 per cent of the greenhouse gas emissions.

[73] This figure combines both household and office furniture. Within ProdCom there is not a clear division between furniture for households or the commercial sector. However, within the UK Economic IO Table the expenditure on furniture by households represents 73% of the total.

[74] UEA (2003) The EU Furniture Industry - Outlook, http: www.ueanet.com/outlook.htm

[75] Personal correspondence with Mr Tub Collins, Director of Furniture Now!

The total amount of energy land (energy footprint) required is 201,000 hectares while another 230,000 hectares of forest land is required for the wood products. This equates to a total ecological footprint of 431,000 hectares.

Soft furnishing

Carpets are sold by area and not weight and there is a very wide spread of products of different specification and construction. In 2000 the total volume of carpets sold through retailers in the UK amounted to 202.7 millions of square metres. Over 64 per cent of carpet sold through retail is imported, the largest part coming from Belgium and Holland. There is still a considerable amount of carpet produced in the UK that is woven, often with a heavy wool based pile. The pile material of such carpets may account for up to 1.5 kg/m^2 and the yarns making up the backing, composed of cotton or polyester, and jute or polypropylene account for a further 1.3 kg/m^2 and the backcoating is approximately 200 g/m^2 of synthetic latex. A cheaper import might have a pile of polypropylene weighing 0.6 kg/m^2 tufted into a woven primary backing, also composed of polypropylene, weighing around 100 g/m^2, having a secondary layer of woven or knitted polypropylene fabric weighing under 90 g/m^2 laminated by about 1 kg/m^2 of latex. Employing these figures consumption in the South East was derived by proportioning this total based on expenditure. In the tables below results of MFA and EF calculations on soft furnishing are presented.

For bedspreads, blankets etc., the composition is assumed to be predominately cotton and wool, with a small proportion of synthetic materials. Taking the figures from ProdCom and verifying the data with relevant trade associations provided the breakdown of hard flooring. By far the most popular hard floor is wood laminate. The material is light in comparison to the floor space it can cover, compared to carpet. However, by weight carpet remains the most significant floor covering.

Table 3.7.15 Material Flow Analysis of the consumption of soft furnishing in the South East

Material	Total Tonnage	Embodied Energy (GJ)	Energy Carriers (tonnes)	Hidden flows of EC (tonnes)	Total MFA (tonnes)	GWP (tonnes)
Soft floor coverings, carpets, mats						
…Cotton/wool	**21,708**	**1,871,794**	**65,391**	**194,421**	**281,520**	140,447
…Polyester	**13,025**	**877,534**	**24,355**	**37,501**	**74,881**	65,844
…Synthetic Rubber	**4,342**	**293,061**	**8,134**	**12,524**	**24,999**	21,989
…Polypropylene	**2,171**	**146,256**	**4,059**	**6,250**	**12,480**	10,974
…Other	**2,171**				**2,171**	
Hard floor coverings, vinyl, tiles etc						
…wood laminate	**7,718**	**1,489,606**	**78,560**	**154,824**	**241,102**	111,770
...Vinyl	**35**	**2,377**	**66**	**102**	**203**	178
...Ceramic tiles	**1,205**	**3,978**	**150**	**383**	**1,738**	298
...Wood	**419**	**15,124**	**798**	**1,572**	**2,789**	1,135
...Stone	**838**	**34**	**1**	**4**	**843**	6
...Rubber	**53**	**3,572**	**99**	**153**	**305**	268
...Cork	**15**	**2,837**	**150**	**295**	**459**	213
Bedspreads, blankets, duvets, pillows, sheets, excluding beds & mattresses	**13,493**	**1,163,409**	**40,644**	**120,842**	**174,978**	87,294
Curtains, cushions, towels etc	**8,869**	**764,709**	**26,715**	**79,429**	**115,013**	57,379
Total	76,062	6,634,291	249,122	608,300	33,481	497,795

The ecological footprint of soft furnishing is 187,744 hectares. Carpets have the most significant impact. This is purely due to higher consumption and not resource productivity.

Table 3.7.16 Ecological Footprint results for soft furnishing in the South East

Category	Energy Footprint (gha)	Land Footprint (gha)	Total Footprint (gha)
Carpets	63,509	23,682	87,191
Hard floor covering	29,478	9,253	38,731
Bedspreads etc.	22,584	14,719	37,303
Curtains	14,844	9,675	24,519
Total	130,415	57,329	187,744

When considering the impact per tonne of product, hard floor covering has approximately double the impact of carpets, in terms of the ecological footprint.

3.8 Direct Energy Consumption

3.8.1 Introduction

The energy required to produce, distribute and market the products and services supplied to residents of the South East (and the resulting carbon dioxide emissions) is separated into the following categories:

- The direct energy, in the form of electricity, natural gas and solid fuels, consumed by households and the service sector within the South East region is considered below.
- The transport energy consumption associated with imported products (outside the UK) and freight transport within the UK for products destined for the South East is considered in Chapter 3.3.
- The energy consumed during the production of goods consumed in the South East is termed the embodied energy and is considered in the product-related Chapters 3.4 to 3.7.[76]

Direct energy is consumed at the household level in the form of electricity, gas, coal, wood and fuel oil[77]. In the UK, there has been a significant shift from solid fuel to natural gas in the 30 years to 2000 (Figure 3.8)[78].

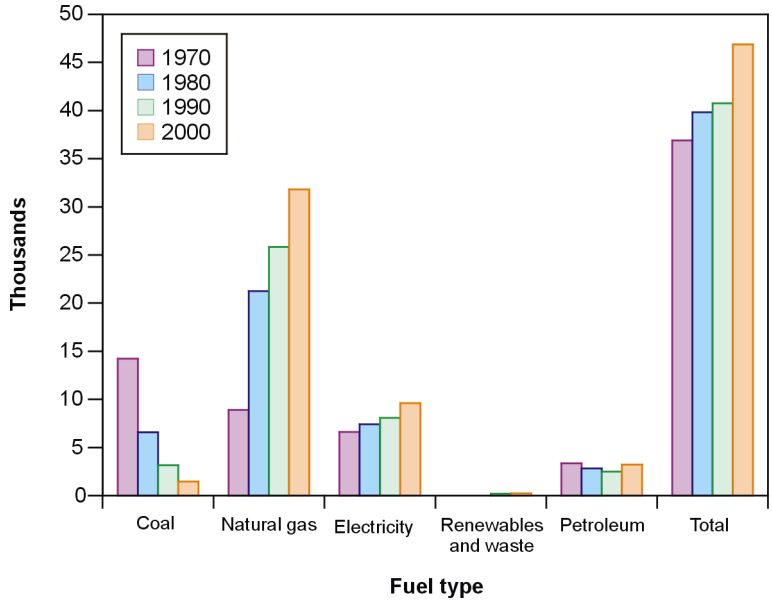

Figure 3.8 UK domestic energy consumption by fuel, 1970–2000 (thousand tonnes of oil equivalent)

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

[76] The energy consumed in industrial and manufacturing production in the SE is not allocated to consumers within the region unless these products are consumed in the SE.

[77] Indirect household energy consumption is the energy required to produce, package and distribute consumer products. Only energy sources that result in carbon dioxide emissions are included in the EF analysis. Therefore, wood (for which the net emissions are zero) is excluded.

[78] There has been a similar shift to natural gas as a fuel for electricity generation.

appliances[79], 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 (see Figures 3.9 and 3.10).

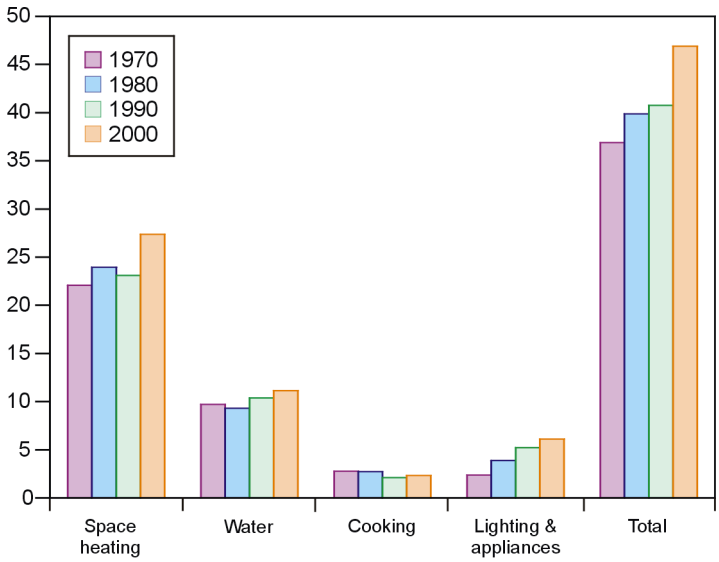

Figure 3.9 Domestic energy consumption by end use, 1970-2000 (million tonnes of oil equivalent)

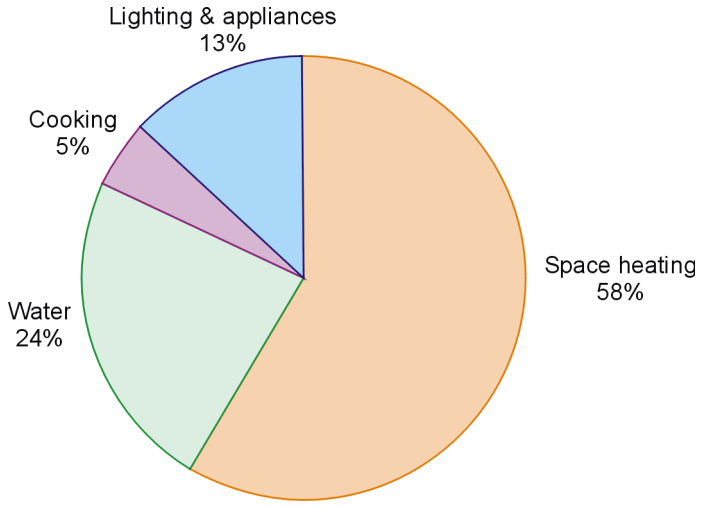

Figure 3.10 Domestic energy consumption by end use, 2000

[79] 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 Chapters 3.3 and 3.7). The resources required during the production of these items, and their disposal in landfill sites, have become topical issues.

3.8.2 The direct energy consumption and associated carbon dioxide emissions of households in the South East

The direct domestic energy consumption in the South East is calculated from Household Expenditure Survey data. This survey provides details of the average expenditure by households in the South East region on energy, with a breakdown for gas, electricity, coal and fuel oil. Information on expenditure is converted into units of energy consumption using the average price for domestic energy supply in the year 2000 (Table 3.8.1)[80].

Table 3.8.1 Energy consumption of households in the South East

	£/household/week	£/year	Price £/kWh, litre or tonne	Total	Total (GWh)	kWh per household
Gas	5.00	878,800,000	0.0159	55,402,849,578 kWh	55,403	16,391
Electricity	5.70	1,001,832,000	0.0732	13,680,996,340 kWh	13,681	4,048
Coal and coke	0.20	35,679,280	181	197,123 tonnes	1,692	0
Fuel oil	0.41	71,358,560	0.18	399,991,928 litres	4,734	118
Total		1,987,669,840			75,510	22,340

DEFRA conversion factors are used to calculate the carbon dioxide (CO_2) emissions associated with each energy source, as different quantities of CO_2 are emitted per unit of energy supplied by each energy carrier (Table 3.8.2).

Table 3.8.2 Carbon dioxide emission factors associated with domestic energy supplies[81]

Fuel Use	CO_2 emissions (kg per kWh)
Electricity (UK average)	0.43
Coal	0.30
Fuel oil	0.26
Petrol	0.24
Natural gas	0.19
Renewables	0

[80] Average prices for gas and electricity were obtained from http://www.dti.gov.uk/energy/inform/energy_prices/tables/table_223.xls and http://www.dti.gov.uk/energy/inform/energy_prices/tables/table_233.xls and breakdown of payment type at http://www.ofgem.gov.
Similar information for fuelwood, coal and fuel oil were obtained from the Forestry Commission and Salkent Ltd.

[81] DEFRA (2003) A Guide to Company Reporting of Greenhouse Gas Emissions (http://www.defra.gov.uk/environment/envrp/gas/index.htm). Wood and renewable energy sources are not included in the energy use and carbon dioxide calculations as the former is part of the carbon cycle and the latter have zero direct carbon dioxide emissions.

The table below shows the total household and per capita carbon dioxide emissions for dwellings in the South East.

Table 3.8.3 Carbon dioxide emissions associated with household energy consumption in the South East (all numbers in tonnes)

Fuel Use	Total HH consumption in the SE (GWh)	CO_2 Emissions (tonnes)	CO_2 Emissions per household (tonnes)	CO_2 Emissions per capita (tonnes)
Gas	55,403	10,526,541	3.022	1.297
Electricity	13,681	5,882,828	1.689	0.725
Coal	1,692	476,841	0.137	0.059
Fuel Oil	4,734	1,202,290	0.345	0.148
Total	75,510	18,088,501	5.19	2.23

Of the different fuels listed in Table 3.8.3, natural gas produces the lowest emissions of CO_2 per kWh. 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, in the last two years, gas price increases have resulted in more coal being used again in power stations. Renewable energy generation could reduce the greenhouse gas emissions associated with the production of electricity and other energy needs significantly.

Concerns about climate change, air pollution and energy security during the last decade have resulted in increased interest in renewable energy (RE) 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 Government Office of the South East have highlighted other benefits associated with RE, including:

- Wealth creation
- Employment generation
- Regeneration
- Rural diversification
- Education and Training
- Environmental Protection
- Eco-tourism

However, in the UK in 2000 renewable energy accounted for just over 1 per cent of energy production. The South East region falls below the national average at 0.65 per cent. At present 95 % of UK carbon dioxide emissions are from fossil fuel use. Renewables are likely to play a significant role in a sustainable energy policy and in meeting targets to reduce greenhouse gas emissions. In the

UK, the target for electricity generated from renewable energy sources is 10 per cent by 2010[82]. A recent report has recommended that the South East set a 'challenging but achievable' target of 750 MW from RE sources for the year 2010. This would represent about 6 per cent of the electricity generation capacity in the region, and be 3 to 4 per cent below the UK target. It should be noted that electricity consumption within the region is currently greater than generation and this target will represent less than 6 per cent of electricity consumption in the region (see Figure 3.11).

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. In 2000, almost all (98.6%) 'renewable' electricity in the South East was generated from waste-to-energy plants.

Renewable energy schemes vary in scale from the use of sustainably produced wood and other biomass at a household level to large hydro schemes. Another distinction is between RE schemes that produce electricity (either for the national grid or for direct consumption) and those that produce non-electrical energy, for example, used for space heating. In 2000 about 75 per cent of RE produced was transformed into electricity.

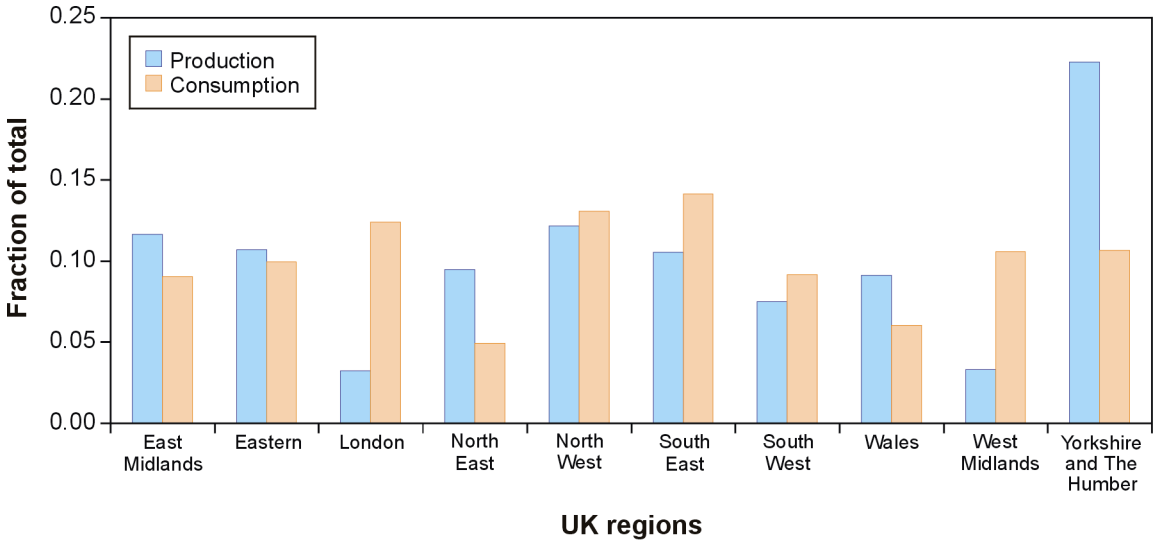

Figure 3.11 Comparison of electricity consumed and produced by RDA[83]

[82] DTI (2001) Digest of UK Energy Statistics, Department of Trade and Industry, London

[83] AEAT (2002) *Key Industrial Environmental Pressures – Air Emissions and Energy Use*. A report produced for Environment Agency by AEA Technology.

3.8.3 Direct energy consumption of the service sector in the South East

The direct energy supplied to the service sector is allocated to the South East as this consumption is not included in the analysis of the embodied energy of products. Services provided for South East residents include:

- Commercial Offices – for banking, insurance and other financial and professional services
- Communication and Transport – offices associated with telecommunications and logistics
- Education – primary, secondary and tertiary
- Government – local, county and (a proportion of) national administration
- Healthcare – in the form of hospitals, surgeries and residential homes
- Catering – for example, restaurants and canteens
- Retail – such as supermarkets, post offices, travel agencies, hairdressers, dry cleaners, etc.
- Sport and Leisure – such as sports centres, museums and cinema.

UK data on direct energy consumption for the service sector were identified and apportioned to the South East on the basis of floorspace or population[84]. The Commercial and Industrial Floorspace and Rateable Value report presents statistics on floor space for non-domestic properties in England and Wales. Information is available for regions, counties and districts as of 1 October 2000. Table 3.8.4 provides information on the direct energy consumption of the service sector in the UK and in the South East region.

Table 3.8.4 Energy consumption in the service sector

Group	UK Energy Consumption (TJ)	Proxy method	SE Energy Consumption	
			TJ	GWh
Retail	159,643	Floorspace	21,516	5,977
Other	132,094	Per capita	17,939	4,983
Education	118,361	Per capita	16,074	4,465
Commercial Offices	99,478	Floorspace	16,238	4,511
Catering	74,693	Per capita	10,143	2,818
Government	50,702	Per capita	6,886	1,913
Health	45,217	Per capita	6,141	1,706
Sport and Leisure	34,876	Per capita	4,736	1,316
Communication and Transport	12,728	Per capita	1,728	480
Total	727,791		101,401	28,169

The associated carbon dioxide emissions for each of the service sectors, with a breakdown by fuel type, is shown in Table 3.8.5.

[84] Commercial and Industrial Floorspace and Rateable Value Statistics 2000, ODPM, HMSO

Table 3.8.5 Carbon dioxide emissions as a result of direct energy consumption of the service sector in the South East, with a breakdown by fuel type (all numbers in tonnes)

Service Sector	Source				Total	
	electricity	gas	heating oil	solid fuel		
Retail	906,567	536,286	237,535	39,807	1,720,196	21%
Other	755,847	447,126	198,044	33,189	1,434,206	18%
Commercial Offices	684,196	404,740	179,270	30,043	1,298,249	16%
Education	677,268	400,642	177,455	29,739	1,285,104	16%
Catering	427,395	252,828	111,984	18,767	810,974	10%
Government	290,121	171,623	76,016	12,739	550,499	7%
Health	258,737	153,057	67,793	11,361	490,949	6%
Sport and Leisure	199,563	118,053	52,289	8,763	378,667	5%
Communication and Transport	72,830	43,083	19,083	3,198	138,193	2%
Total	4,272,522	2,527,439	1,119,470	187,606	8,107,037	

3.8.4 The Ecological Footprint of direct energy consumption

The CO_2 emissions associated with direct energy consumption in the domestic and service sectors are converted into the Ecological Footprint by considering the amount of land required to sequester the pollutant. Table 3.8.6 provides an example of how the CO_2 emissions are converted into an Ecological Footprint, in this instance for natural gas.

Table 3.8.6 The Ecological Footprint conversion factor for natural gas combustion

GWP / GWh (tonnes of CO_2 equivalent)	Energy Land (ha)	Equivalence Factor (gha/ha)	Ecological Footprint (gha/GWh)
190	36.54	1.35	49.15

190 tonnes of CO_2 are emitted when burning natural gas to produce 1 GWh[85] of electricity. This figure is converted into the amount of land required to absorb the CO_2 (5.2 tonnes of CO_2 is absorbed by 1 hectare of forest).

$$190 \div 5.2 = 36.54 \text{ ha}$$

Global equivalence factors have been applied to the Ecological Footprint calculations. The global equivalence factor compares the biomass of all the different land types to assess the amount of productive area that is being appropriated. More precisely, these factors inform us about the category's relative yield as compared to world average land.

36.54 x 1.35 (global equivalence factor for forest land) = 49.15 gha.

[85] 1 GWh is equivalent to 1,000,000 kWh

Therefore, the Ecological Footprint for producing 1 GWh of gas is 49.15 global hectares. The Ecological Footprint associated with the production of 1 GWh of energy, in the form of fossil fuels and electricity is given in the table below.

Table 3.8.7 The Ecological Footprint of producing 1 GWh of energy from different energy sources

Fuel	Ecological Footprint (gha/GWh)
Gas	49
Petrol	62
Fuel Oil	67
Coal	78
Electricity	111

Therefore, to calculate the Ecological Footprint of direct energy consumption in the South East, the total amount of energy supplied by each source is multiplied by the appropriate conversion factor.

Table 3.8.8 Ecological footprint of direct energy for the domestic and service sector

		Energy consumption (GWh)	CO_2 emissions (tonnes)	Fuel combustion EF	Transport-related EF	Total EF	EF per capita
Domestic and Service	Electricity	23,617	10,155,351	2,627,268		2,627,268	0.324
	Gas	68,705	13,053,980	3,377,166	27,333	3,404,500	0.420
	Fuel oil	9,040	2,321,760	608,057	8,226	616,283	0.076
	Coal	2,317	664,447	179,864	29,317	209,181	0.026
	Total	103,680	26,195,538	6,792,355	64,876	6,857,232	0.845
Domestic Sector	Electricity	13,681	5,882,828	1,521,933		1,521,933	0.188
	Gas	55,403	10,526,541	2,723,298	20,734	2,744,032	0.338
	Fuel oil	4,734	1,202,290	318,442	4,358	322,800	0.040
	Coal	1,692	476,841	131,328	17,400	148,728	0.018
	Total	75,510	18,088,501	4,695,002	42,492	4,737,493	0.584
Service Sector	Electricity	9,936	4,272,522	1,105,335		1,105,335	0.136
	Gas	13,302	2,527,439	653,868	6,600	660,468	0.081
	Fuel oil	4,306	1,119,470	289,615	3,868	293,483	0.036
	Coal	625	187,606	48,535	11,917	60,453	0.007
	Total	28,169	8,107,037	2,097,354	22,385	2,119,738	0.261

The total Ecological Footprint of direct energy consumption in 2000 in the South East was 6.8 million hectares or 0.845 hectares per capita. Domestic energy consumption accounted for 69 per cent of this total (0.584 hectares per capita) and the service sector for the remaining 31 per cent. Domestic gas consumption has the highest Ecological Footprint (0.34 hectares per capita) followed by domestic electricity consumption (0.19 hectares per capita).

3.8.5 Material Flow Analysis for direct energy consumption

Table 3.8.9 provides the results of the material flow analysis (MFA) for direct domestic and service sector energy consumption in the South East.

In total, 7.5 million tonnes of fuel is required to provide households in the South East with all their direct energy requirements. An additional 5.8 million tonnes of hidden flows are required to provide this fuel. For households in the region, 13.4 million tonnes of materials are associated with energy carriers. The outputs are 18.3 million tonnes of greenhouse gas emissions and 5.8 million tonnes of hidden flows. In the case of the service sector, 7.5 million tonnes of inputs results in 12.4 million tonnes of greenhouse gas emissions and hidden flows. The input into the domestic and service sector combined amounts to 20.9 million tonnes which results in 28.4 million tonnes of greenhouse gas emissions and 10.1 million tonnes of hidden flows. This equates to 2.6 tonnes per capita input and 4.5 tonnes per capita output.

Table 3.8.9 Mass balance data of direct energy consumption for the domestic and service sector in the South East (all numbers in tonnes)

	Material Input tonnes		Material Output tonnes	
DOMESTIC	*Energy Carriers*		*Greenhouse Gas Emissions*	
	Electricity	2,486,450	Electricity	5,882,828
	Gas	4,467,668	Gas	10,526,541
	Fuel Oil	391,796	Fuel Oil	1,202,290
	Coal	197,139	Coal	664,447
	Subtotal	7,543,053	Subtotal	18,276,107
	Hidden Flows		*Mine Dumping and Back-filling*	
	Electricity	5,816,649	Electricity	5,816,649
	Total	13,359,702	Total	24,092,756
	Material Input Tonnes		Material Output tonnes	
SERVICE SECTOR	*Energy Carriers*		*Greenhouse Gas Emissions*	
	Electricity	1,805,834	Electricity	4,272,522
	Gas	1,072,694	Gas	2,527,439
	Fuel Oil	356,330	Fuel Oil	1,119,470
	Coal	72,857	Coal	187,606
	Subtotal	3,307,715	Subtotal	8,107,037
	Hidden Flows		*Mine Dumping and Back-filling*	
	Electricity	4,224,458	Electricity	4,272,522
	Total	7,532,173	Total	12,379,560
	Material Input tonnes		Material Output tonnes	
DOMESTIC and SERVICE	*Energy Carriers*		*Greenhouse Gas Emissions*	
	Electricity	4,292,284	Electricity	10,155,351
	Gas	5,540,362	Gas	13,053,980
	Fuel Oil	748,126	Fuel Oil	2,321,760
	Coal	269,996	Coal	852,054
	Subtotal	10,850,768	Subtotal	26,383,144
	Hidden Flows		*Mine Dumping and Back-filling*	
	Electricity	10,041,107	Electricity	10,089,171
	Total	20,891,875	Total	36,472,316

3.9 Water

3.9.1 Introduction

Water consumption and supply have become increasingly important issues in the UK, particularly in South and East England. Rainfall in the Southern region of England, for example, is 20 per cent below the average for England as a whole[86]. The environmental impacts of water consumption and treatment include the energy used during the supply and waste treatment of water, the generation of sewage sludge and methane emissions at waste treatment plants. As with other areas of this report, it is the domestic and service sectors that are covered and industrial water consumption is not considered.

3.9.2 Water consumption by households and the service sector in the South East

In England and Wales about half of all water use is for electricity generation at power stations. Public water supply, which includes domestic and the service sectors accounts for 30 per cent of consumption (Figure 3.12).

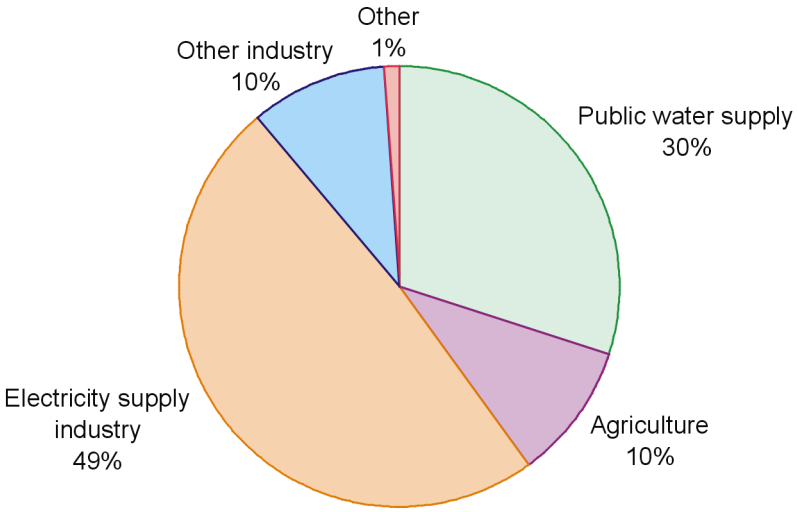

Figure 3.12 Water abstractions in England and Wales from all surface and groundwater sources by purpose[87]

The South East accounts for 16.7 per cent of all household water use in England and Wales. Household water consumption in the South East amounts to 165 litres per capita per day, which is equivalent to over 60,000 litres per person each year[88]. Although increasing, only 15 per cent of domestic water supplies are metered. This is significant as on average, 13 per cent less water is consumed in households that have a metered water supply.

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[86] Institute of Hydrology (2001) *Waterfacts, 2000*.
[87] DEFRA (2002) Digest of environmental statistics. Department for Environment, Food and Rural Affairs
[88] AEAT (2002) *Key Industrial Environmental Pressures - Water Use*. A report produced for Environment Agency by AEA Technology.

Table 3.9.1 Water consumption in the South East

	Water Supply (million litres / year)	Water Supply (thousand litres /capita)
Household	**488,551**	**60**
Service Sector	**55,961**	**7**
Leakages	**219,144**	**27**
Total	**763,657**	**94**

In total 544 billion litres of water was supplied to households and the service sector in 1999 and leakages stood at almost 220 billion litres[89]. Therefore, over 28 per cent of all water pumped did not reach the consumer in that year due to leakages. Domestic water consumption in the South East is 9 per cent higher than the national average (Figure 3.13).

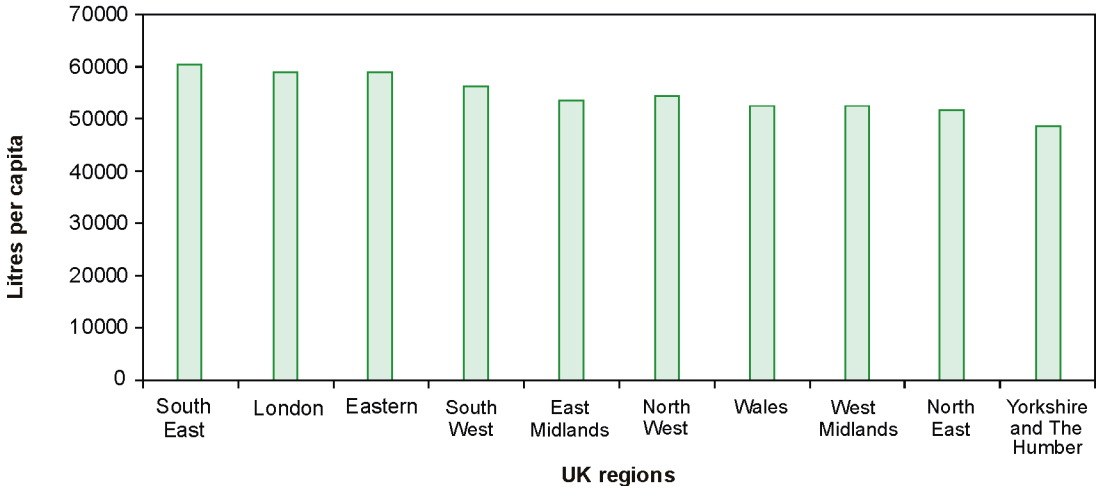

Figure 3.13 Per capita water consumption for households per year

A study by Anglia Water found that almost a third of household water consumption is through flushing a WC, while 15 per cent is used through bathing and the kitchen sink (Figure 3.14).

[89] Services that are considered are based on SIC-92 and comprise: Retail; Public Administration and Defence; Education; Health & Social and Recreation; and Culture & Sport. This information was obtained from AEAT (2002).

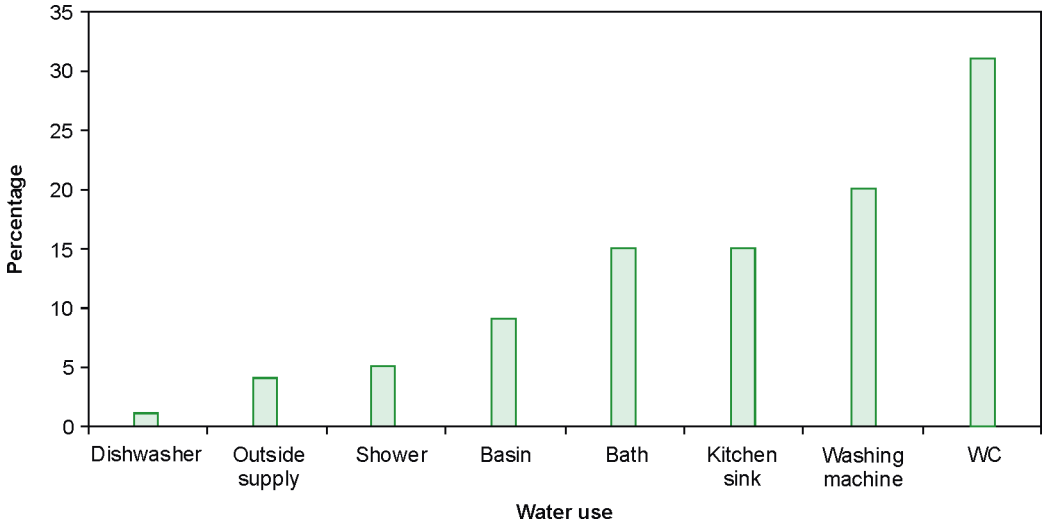

Figure 3.14 Household water consumption by use

3.9.3 The energy consumption and carbon dioxide emissions associated with water supply

As Southern Water covers a large part of the South East RDA area, source data for the energy required to supply and treat water in this region were used rather than the UK average[90]. The energy consumption associated with water supply in the South East was 20 per cent less efficient than the UK average at 536.6 kWh per million litres of water. Additionally, renewable energy use at fixed sites in the South East stood at less than 1 per cent compared to a UK average of almost 4 per cent. The energy consumed in treating waste water was, however, 12 per cent lower than the national average.

In total, the energy consumed during the supply and treatment of water for the domestic and service sectors amounted to 856 GWh, which resulted in 368 thousand tonnes of carbon dioxide emissions.

Table 3.9.2 Energy use and carbon dioxide emissions associated with water supply and treatment in the South East

	Energy use (GWh)	CO_2 Emissions (tonnes)
Supply		
Household	**317**	**136,130**
Service Sector	**36**	**15,593**
Leakages	**142**	**61,062**
Outputs		
Waste water treatment	**362**	**155,470**
Total	**856**	**368,256**

[90] In 2000/2001, the energy required to supply and treat a million litres of water in the Southern Water region, was 648 kWh and 387 kWh, respectively. This was reported in Southern Water (2002) Sustainability Report 2001/02 at http://www.southernwater.co.uk/corporate_zone/the_library/sustainability_performance_report/SustainabilityReport.pdf

3.9.4 The Ecological Footprint of water supply and wastewater treatment

The Ecological Footprint of water supply amounted to 95,605 hectares or 0.012 hectares per capita.

Table 3.9.3 The Ecological Footprint of water supply in the South East (all numbers in global hectares)

	Total EF	EF per capita
Supply		
Household	**35,341**	**0.0044**
Service Sector	**4,048**	**0.0005**
Leakages	**15,853**	**0.0020**
Outputs		
Waste water treatment	**40,363**	**0.0050**
Total	**95,605**	**0.0118**

3.9.5 Material Flow Analysis of water supply

Inputs and outputs associated with water supply in the South East region are described in the table below. The main input is, of course, water, of which over 763 million tonnes was supplied to consumers (or was leaked). The other main inputs are energy carriers and the hidden flows associated with these. Outputs include sewage sludge, carbon dioxide emissions and methane emissions.

Table 3.9.4 Mass balance data for South East water supply (all numbers in tonnes)

Inputs		Outputs	
Water	**763,657,000**	**Wastewater treated**	**934,261,000**
		Sewage sludge (solid)	**153,466**
Energy Carriers	**155,648**	**Carbon dioxide emissions**	**368,256**
		Methane emissions	**4,891**
Energy Carriers (hidden Flows)	**364,113**	**Energy Carriers (hidden Flows)**	**364,113**

Until recently, about a quarter of sludge was either dumped at sea or discharged to surface waters. The implementation of an EU Directive in 1998 prohibited this form of disposal because it was considered environmentally unacceptable. Use of sludge as a soil conditioner and fertiliser on agricultural land remains the environmentally favoured option, however, sewage sludge can only be recycled to certain crops and vegetations and there is the risk of pollution through heavy metals and persistent organic pollutants[91].

[91] Based on information from OFWAT, Scottish Executive and DOE compiled by DEFRA at http://www.defra.gov.uk/environment/water/quality/uwwtd/report02/07.htm