

The carbon emissions generated in all that we consume



Preface

Business increasingly recognises the need to cut carbon emissions. A variety of different factors are driving this including higher energy costs, the need for energy security and climate change. Climate change poses its own set of challenges and opportunities including changes in consumer demand for products and services, compliance with regulation, new risks to brand value and changes in shareholder demands. Over time, their magnitude will be significant but will vary from industry to industry and between companies.

Information is widely available on the carbon emissions associated with different industries, and also on the potential of those industries to reduce carbon emissions. What is less well understood is how those emissions translate into the carbon impact of the products and services ultimately delivered to the UK consumer. This 'consumption-based view' has the potential to allow business to target those consumer products and services which have highest overall carbon emissions. Business should then be able to proactively reduce carbon emissions throughout the supply chain in a way that also delivers financial benefits over time.

For this reason, the Carbon Trust initiated this study to attribute all carbon emissions to final product and service categories. The modelling and analytical work for this study was completed by the Centre for Environmental Strategy at the University of Surrey and Enviros Consulting. This report describes the work undertaken and presents the carbon footprint of the most carbon intensive products and services consumed in the UK.

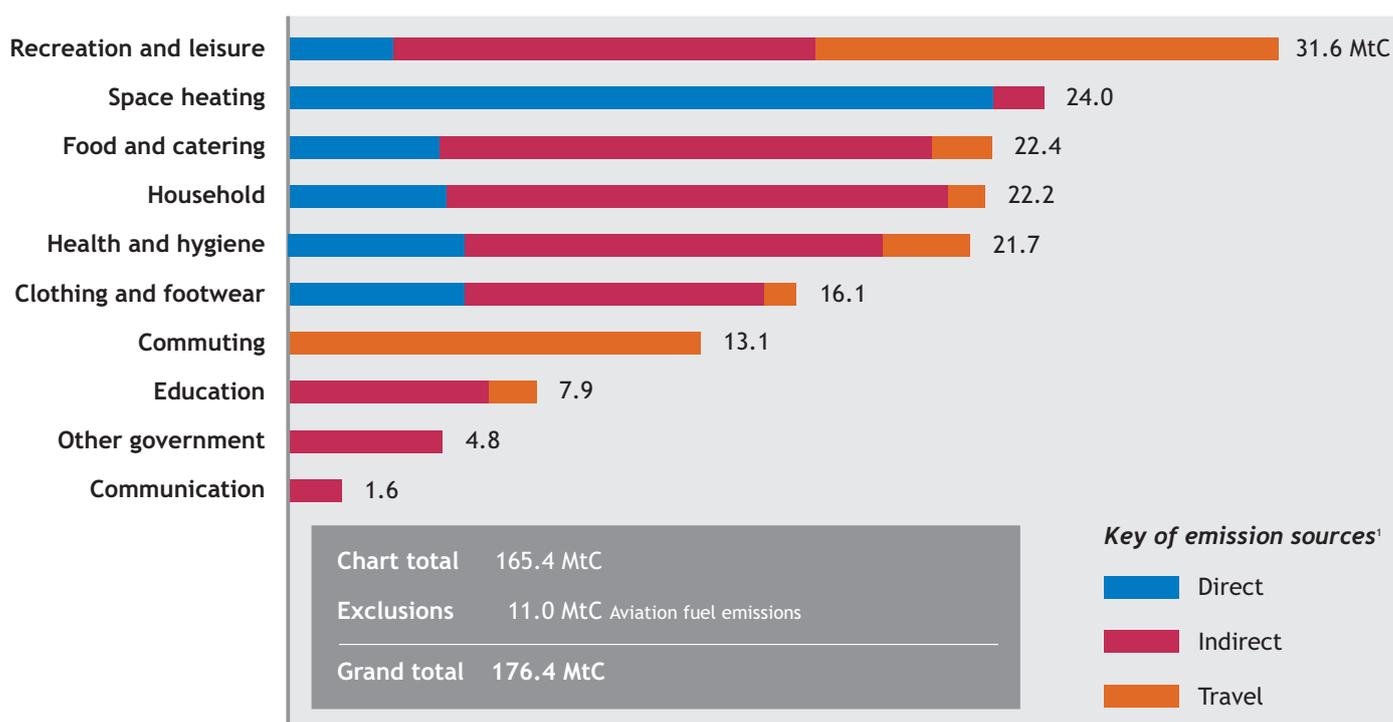
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Key findings

- ▶ Consumer purchasing decisions are the ultimate driver of carbon emissions in an economy. All carbon emissions can be attributed to the delivery of products and services to meet the needs of the consumer;
- ▶ UK consumers use products and services with a combined carbon footprint of 176.4 MtC (millions tonnes carbon per annum). This is 11.7 MtC greater than the emissions from all UK production. This means that the UK is a net importer of carbon intensive products and services from abroad;
- ▶ All product and service emissions can be classified into high-level consumer needs categories as outlined in the chart below. Recreation and Leisure, Space Heating and Food and Catering are the three consumer needs with the highest carbon emissions. Together, they account for almost half of the total UK carbon emissions; and
- ▶ As we move to a more carbon-constrained world, business will have to continue to meet customer needs but in a way that generates fewer carbon emissions. The approach outlined in this report has the potential to allow business to identify the most carbon intensive products and services and prioritise areas where further emission reductions can be achieved.

Summary chart: A split of all emissions by high-level consumer need



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

¹ Direct emissions are the emissions associated with the direct consumption of (non-transport related) fossil fuels and electricity in the household. Indirect emissions include the emissions embodied in goods and services, including energy required to produce the goods and services and the emissions from space heating and lighting by the service and government sectors. Travel-related emissions include emissions from transport fuels and the indirect emissions embodied in transport goods and services.

Executive summary

The aim of the study was to increase the understanding of the fundamental drivers of carbon emissions in the UK and to show how all carbon emissions can be attributed to the delivery of products and services to meet the needs of the end consumer. From this work, it is possible to identify the products and services which have the highest carbon emissions associated with their supply chains.



This approach is a departure from much of the analysis in this area to date which presents carbon emissions by industrial sector. This new analysis works on the principle that all industrial emissions can ultimately be tied back to the provision of one or more consumer products or services.

The study was undertaken on behalf of the Carbon Trust by the Centre for Environmental Strategy at the University of Surrey and Enviros Consulting. The analysis was based on an economic model developed at the University of Surrey, which analysed the UK's carbon emissions in terms of the total carbon embodied in consumer products and services.

The model used in the analysis combines emissions created throughout the supply chain to give a measure of the total emissions associated with the provision of individual products and services. Typically, this includes raw material extraction, manufacturing, distribution, retailing, consumption, disposal and recycling. Analysing carbon emissions in this way provides a powerful insight into how the daily decisions by individual consumers drive economy-wide carbon emissions.

For example, some of the carbon efficiency improvements in recent years have been negated by increases in consumer demand, such as in aviation where increases in aero engine efficiency have been negated by an increase in the number of flights.

By analysing the carbon emissions embodied in consumer products and services, business is better placed to:

- ▶ Manage the wider supply chain impacts associated with a more carbon-constrained world;
- ▶ Make better long-term investment decisions by taking into account the value of carbon; and
- ▶ Ultimately identify more radical product replacement strategies that reduce carbon emissions as well as delivering improvements to the financial bottom line.

The results of the analysis can be cast in a variety of ways depending on the classifications used. The study starts with an analysis of the traditional production perspective and then reclassifies carbon emissions into consumption categories before combining those categories into high-level consumer needs categories. This analysis leads to the following general conclusions:

From the traditional production perspective:

- ▶ The Electricity Production category has the highest emissions at almost 24 MtC (millions tonnes carbon per annum);
- ▶ The Other Land Transport category (comprising road freight, buses and coaches, taxis etc.) and the Refining Industries category have second and third highest emissions at 7.9 MtC and 7.1 MtC respectively; and
- ▶ The categories relating to the provision of final products and services to the consumer all have emissions of less than 2 MtC.

This perspective shows total emissions of 88.1 MtC. It excludes aviation fuel emissions (11.0 MtC), domestic electricity (22.0 MtC), domestic fuel use (25.3 MtC), domestic private transport fuel use (18.3 MtC) and the UK carbon trade balance (11.7 MtC), totalling 88.3 MtC.

The emissions can then be reallocated from this traditional production perspective to different consumption perspectives. For each individual product or service, the carbon emissions generated by the economic activity needed to supply them is summed together to give a full picture of all the carbon attributable to that product or service. In these consumption perspectives, the additional emissions from the UK carbon trade balance are included.

This reallocation shows that:

- ▶ The emissions from Electricity Production can be completely reallocated to the end user categories of that electricity. For example, the Hotels, Catering and Pubs category now includes the emissions from the generation of the electricity used to heat hotels and refrigerate and cook restaurant food; and
- ▶ The supply chains in the Hotels, Catering and Pubs category now have the largest carbon emissions at 8.3 MtC. This is followed by Motor Vehicle Production and Health and Veterinary Services, at 7.1 MtC and 6.1 MtC respectively.

Finally, the consumption categories can be summed together into high-level consumer needs. In these perspectives, emissions from domestic electricity, domestic fuel use and domestic private transport fuel use are added in. Aviation fuel emissions are still excluded.

This perspective shows:

- ▶ The supply chains associated with Recreation and Leisure have the highest emissions at 31.6 MtC. Just under half of this is transport emissions;
- ▶ This is followed by Space Heating of buildings with 24.0 MtC and Food and Catering at 22.4 MtC. The majority of Space Heating emissions occur directly in the building, whereas two thirds of carbon emissions from Food and Catering are embodied in the products consumed; and
- ▶ In total, UK consumers use products and services with a combined carbon footprint of 176.4 MtC. This is 11.7 MtC greater than the emissions from all UK production. This means that the UK is a net importer of carbon intensive products and services from abroad.

At each stage of reclassification, different categories come to the fore in terms of their carbon emissions. This illustrates the opportunity open to business to target different products and services by considering different parts of the supply chain or even whole supply chains. The use of the approach outlined in this report has the potential to yield insight on how to deliver significant carbon savings over time, through the adoption of new technologies and services that modify or replace existing carbon intensive ways of meeting consumer needs.

1 Introduction

The mitigation of climate change requires fundamental changes over time to the way that business delivers products and services to the end consumer. The level of the challenge is reflected in the target set by Government to reduce carbon emissions in the UK by 60% from 1990 levels by 2050, as set out in the 2003 Energy White Paper.



Historically, efforts to reduce carbon emissions have mainly focused on emissions from more energy intensive industry. Greater business engagement in the issue of climate change through regulation and incentives and the growth of the service-based economy have reduced the carbon intensity of UK business.

Many products and services generate greater emissions from their use than the emissions created during their production. Examples include:

- ▶ **Motor vehicles:** Where emissions from the production of the vehicle and drilling and refining of the fuel are smaller than the emissions from driving the vehicle over its lifetime; and
- ▶ **Clothing:** Where emissions from the manufacture of clothing, washing machines and detergent are smaller than from the electricity used in washing, drying and ironing the clothes in their lifetime.

In addition, the rate of increase in consumption of a number of consumer products has exceeded improvements in upstream energy efficiency. This has resulted in an overall increase in carbon emissions from the associated supply chains.

Broadly speaking, four stages of evolution can be identified in the way that business can reduce carbon emissions over time and realise associated financial benefits:

Stage 1: Energy Efficiency – this focuses efforts on reducing energy-related emissions in a tactical way in company buildings or sites. For further details see www.thecarbontrust.co.uk/energy

Stage 2: Carbon Management – this prioritises emission reduction efforts across all directly controlled emission sources and adds a strategic dimension to increase understanding of the business risks and opportunities associated with climate change and the transition to a low carbon economy. For further details see www.thecarbontrust.co.uk/carbonmanagement

Stage 3: Supply Chain – this optimises opportunities to reduce emissions and improve financial performance through analysis of life-cycle carbon impacts and costs from raw materials to product disposal across the whole supply chain; and

Stage 4: Product Replacement – this focuses on designing appropriate products and services to fulfil consumer needs in a much less carbon-intensive manner and hence capture the business opportunities associated with the shift to a low carbon economy.

Stages 1 and 2 are being addressed by a variety of interventions across business, including a suite of products offered by The Carbon Trust. The achievement of the UK's carbon reduction targets will however require much deeper cuts in emissions over time, so there is also a need to consider approaches across stages 3 and 4.

In short, to meet the 2050 target business needs to develop innovative strategies which challenge the way in which consumer needs are satisfied and which move beyond incremental improvements in process efficiency.

To develop this new approach, the Carbon Trust commissioned Enviro Consulting and the Centre for Environmental Strategy at the University of Surrey to provide an analytical framework and supporting evidence base. This report describes the results of that work and provides the basis for a strategic discussion across a range of government and business stakeholders.

1.1 Context and objectives

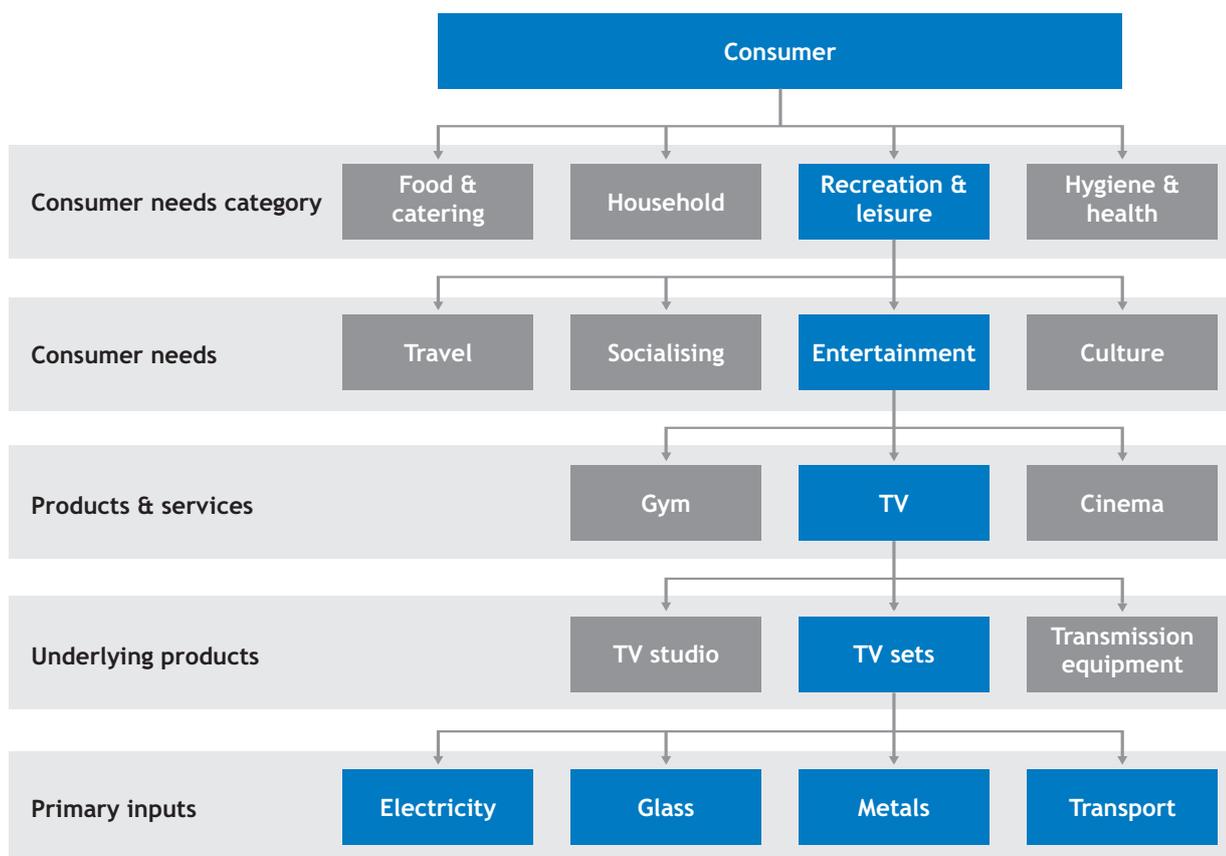
The premise of this study is that the driver of carbon emissions in the UK economy lies ultimately with the satisfaction of consumer needs and desires. Or to be more precise, that the consumer demand for products and services is what drives the production processes that consume energy resources and emit carbon.

From a production perspective, categories such as Electricity Production and Iron and Steel are amongst the most carbon-intensive in the economy. From a consumer demand perspective, however, electricity and iron and steel are not consumed directly but are 'primary inputs' in the satisfaction of a wide variety of consumer needs. Figure 1 shows a consumption chain for television sets. The chain illustrates how the satisfaction of a consumer need drives the use of primary inputs and so is ultimately driving the associated carbon emissions.

The overall aim of this study was to develop an approach to allocate carbon emissions across the supply chain to consumer products and services, in such a way that the level of carbon emissions attributable to each is scaled according to the consumer demand for that particular product and service. This includes all the 'upstream' and 'downstream' carbon induced in the economy in the provision of that product or service. In doing this, all UK carbon emissions can be recast from the perspective of production to the perspective of consumption.

The intention was to move as high up the consumption chain as possible in order to identify the most carbon intensive consumer needs as well as those products and services which have the highest carbon impacts throughout their life cycle. The ranking of products and services according to life cycle carbon emissions can then be used to prioritise areas where further carbon reductions could be achieved.

Figure 1: Consumption chain for television sets



1.2 Methodology

The methodology employed in the project builds on an input-output accounting model developed at the Centre for Environmental Strategy at the University of Surrey. The model is based on the work of Wassily Leontieff² and later developments of this framework to account for international trade³.

Production perspective

The first stage is to categorise emissions using a traditional production perspective. The production-based model uses the 1992 Standard Industrial Classification to define 122 industrial commodity categories. The volume and type of fossil fuel used by each category is taken from the 2002 UK Environmental Accounts in the National Accounts compiled by the Office for National Statistics (ONS). The data are mapped against each individual category to give volume and type of fossil fuel used by each category.

Different fuel types emit different levels of carbon when burned. The 1996 revised IPCC carbon coefficients describe the relationship between the type of fuel burned and associated carbon emissions. For each category, the IPCC coefficients are used to translate the volume and type of fuel burned into carbon dioxide emissions for that category⁴.

The carbon dioxide emissions from burning fossil fuels are then translated into carbon emissions. These are summed together to give the total carbon emissions for each category. It is these emissions that are presented in this report.



Consumption perspective

The consumption model uses the most recent 1995 UK Input-Output Analytical Tables⁵ based on 122 industrial commodity categories to construct a two-region model incorporating trade between the UK and the rest of the world. The input-output model is used here as it allows emissions to be easily reclassified from one category to another. Ultimately, this allows the supply chain emissions for final consumer products and services to be built up. For example, in the production of TV sets, the emissions to generate the electricity used in the TV component manufacture are reclassified from the Electricity Production category into the Electrical Goods category.

Again, the volume and type of fossil fuel used by each category, taken from the ONS 2002 UK Environmental Accounts, is mapped against each of the 122 categories. The 1996 revised IPCC carbon coefficients are again used to translate the volume and type of fuel burned into carbon emissions for each category.

Ultimately, however, it is the consumer demand for final products and services that drives carbon emissions. The input-output model allows all the carbon 'induced' directly and indirectly in the production of a product or service to be reclassified against each product and service type. In this perspective, emissions are scaled according to:

- 1) The level of demand for each product or service; and
- 2) The carbon intensity of producing all the upstream inputs required to deliver the product or service to consumers.

² Leontieff, W., *Input-Output Economics*, Oxford University Press, New York, 1966.

³ Proops, J., Faber, M. and Wagenhals, G., *Reducing CO₂ emissions – a comparative input-output study for Germany and the UK*, Springer-Verlag, Germany, 1993; Papathanasopoulou, E., and Jackson, T., *Testing Dematerialisation and International Pollution Coefficients*, International Society for Industrial Ecology (ISIE) Conference, Ann Arbor, Michigan 2003; Jackson, T and Papathanasopoulou, E., *Material Implications of Household Consumption – with reference to UK expenditure patterns 1968-2000*, ISIE Conference, Montreal, Canada 2004; Jackson, T., Papathanasopoulou, E. and Bradley, P., *Attributing UK carbon emissions to functional consumer needs: methodology and pilot results*, RESOLVE working paper V1/0601, University of Surrey, 2006.

This approach gets closer to assessing the carbon implications of different consumer needs.

Geography is also a key consideration. Traditional production-based carbon accounting methodologies tend to calculate carbon emissions on the basis of production outputs within geographical boundaries. Emissions are calculated on the basis of all the carbon associated with, for example, UK-based (or sometimes UK-owned) production facilities.

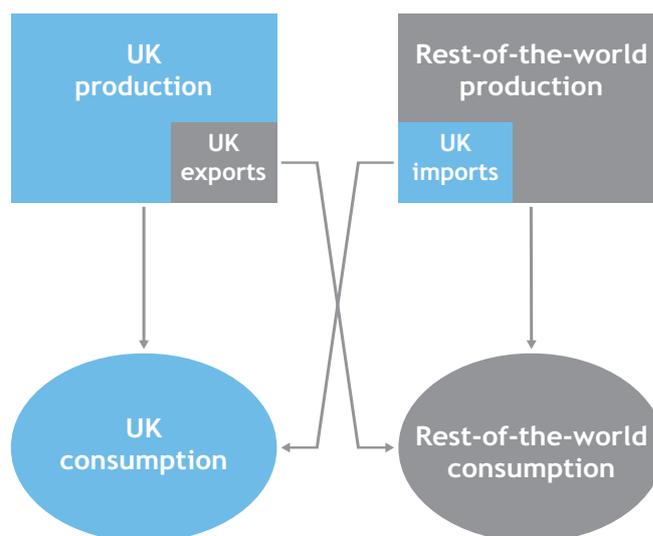
From a consumer demand perspective, however, it is more appropriate to investigate the carbon attributable to the demand for products and services from UK consumers, irrespective of where those products and services were produced. The input-output model uses two regions to adjust the emissions from each category to take this into account. This is illustrated in Figure 2.

The model splits emissions generated within the UK into two: those that are from the supply chain of products and services for the UK consumer (light blue) and those that are for consumption overseas (grey). Because the ultimate goal is to look at emissions from the perspective of UK consumption, the emissions associated with the overseas exports are removed. This leaves the emissions from products and services that are both UK produced and UK consumed.

For consistency, emissions from products and services which are produced overseas but are consumed by UK consumers are added in. This complete consumption picture now includes emissions from all products and services consumed in the UK, regardless of where the emissions were generated.

A key assumption in the model is that products and services imported from abroad are assumed to have the same carbon footprint as those produced in the UK. In practice there will be some differences but these have not been accounted for in the study. Intuitively, differences will be largely due to differences in electricity generation technologies, process fuel mix, levels of automated production and different modes of transport used in the exporting countries.

Figure 2: Two-region carbon attribution model



⁴This report only considers the energy-related carbon dioxide emissions (counted in millions of tonnes of carbon per annum) associated with each product and service category. It omits non-energy related CO₂ emissions and also other greenhouse gas emissions such as methane and nitrous oxide. Office for National Statistics. 2004 United Kingdom Input-Output Analyses, 2004 edition. London, HMSO.

⁵Office for National Statistics 2002. UK Input-Output Analytical Tables, 1995. London HMSO.

2 Carbon accounts

In the course of this study, the model has been used to prepare six distinct sets of carbon accounts. Each new account builds on the outputs from the previous account to translate from a production perspective to a consumption perspective where all emissions are reclassified against different consumer needs:

▶ A. Production-based Account

A conventional breakdown of UK production including UK exports and excluding UK imports;

▶ B. Consumption-based Account

Showing carbon emissions attributed to final demand for products and services, including emissions from imports and excluding exports;

▶ C. Consumption-based Account with Fixed-capital Reallocated

Showing the reallocation of carbon emissions from buildings and other supply chain infrastructure to product and service categories;

▶ D. Consumption-based Account with Fixed-capital and Distribution Reallocated

Showing the reallocation of emissions from wholesale, retail and motor vehicle distribution categories to final product and service categories. The reallocated emissions are mainly from electricity and fuel use in retail stores, warehouses and transport emissions. The distribution categories exclude aviation fuel emissions as described opposite;

▶ E. Domestic Functional Use Account

Showing the reallocation of emissions to different consumer expenditure categories such as Space Heating, Private Transport and Household Appliances; and

▶ F. High-level Consumer Needs Account

Showing the reallocation of emissions to high-level consumer needs such as Food and Catering, Recreation and Leisure, and Hygiene and Health.

The accounts show the step by step process to reallocate carbon emissions from the conventional production perspective to the different consumer needs perspectives. This is equivalent to the build-up from primary inputs through products and services to consumer needs as shown in the consumption chain in Figure 1.



Transport

The treatment of transport is complicated by two factors:

- ▶ Complexity in establishing the boundaries for aviation fuel emissions and water transport (e.g. shipping) emissions because both categories traverse international borders. Conventional UK accounts tend to include only emissions from UK companies; and
- ▶ The UK National Travel Survey excludes overseas travel patterns. It is, therefore, difficult to allocate international aviation fuel emissions to high-level consumer needs. This report does not attempt to complete this reallocation.

To deal with this complexity and to make the results as meaningful as possible, the following approaches have been taken (in all cases, data from ONS 2002 UK Environmental Accounts are used):

Emission type	Approach taken
Domestic private transport emissions	Excluded from Accounts A to D but included in Accounts E and F
Water transport (shipping) emissions	Included throughout Domestic water transport emissions included International water transport emissions included where they relate to inbound imports of products and services for the UK consumer
Aviation fuel emissions	Excluded from Accounts A to F but included in the final reconciliation of consumption and production in section 2.3 Domestic and international emissions from fuel used by UK-registered airlines included
Rail transport	Included throughout
Other land transport (comprising road freight, buses and coaches, taxis etc.)	Included throughout

2.1 Production and consumption accounts

Accounts A to D illustrate the reallocation of carbon from a production to a consumption perspective. Each set of accounts are described in the following sections. The accounts have been colour coded to group categories according to the following types:

- **Mainly final products**
Products provided to the end consumer by the private sector such as motor vehicles, alcoholic beverages, soaps and toiletries
- **Mainly commercial services**
Services provided to the end consumer by the private sector such as hotels, restaurants and telecoms
- **Mainly public services**
Services provided to the end consumer by the government such as health, education and social work services
- **Mainly intermediate products**
Primary and manufacturing outputs which are used as inputs in the manufacture of final products and the provision of final services to the end consumer. Examples include steel, fertilisers and chemicals
- **Distribution and transport**
Distribution encompasses the infrastructure to provide products and services to the end consumer such as retail stores, warehouses and vehicle dealerships. Details of the specific treatment of each transport type are described in section 2
- **Delivered fuels, utilities and agriculture**
Electricity, gas and other fuel generation and distribution along with water and waste services and agriculture

The colour coding emphasises the shift that occurs as the analysis moves from production to consumption. Final products and services are coloured dark blue, red and orange. They can be seen to move up the scale as we move from Account A through to Account D, as intermediate products, distribution and delivered fuels, utilities and agriculture are allocated to the final product and service categories.

It is important to note that Accounts A to D exclude emissions directly from households such as emissions from delivered fuels, emissions from generation of domestic electricity and private transport fuel emissions. These are treated separately in the Domestic Functional Use Account (Account E) and High-level Consumer Needs Account (Account F).

For presentational purposes, only the top 25 emitting categories are presented here. Some of the 1992 Standard Industrial Classification categories have been renamed to aid clarity.

▶ A. Production-based Account

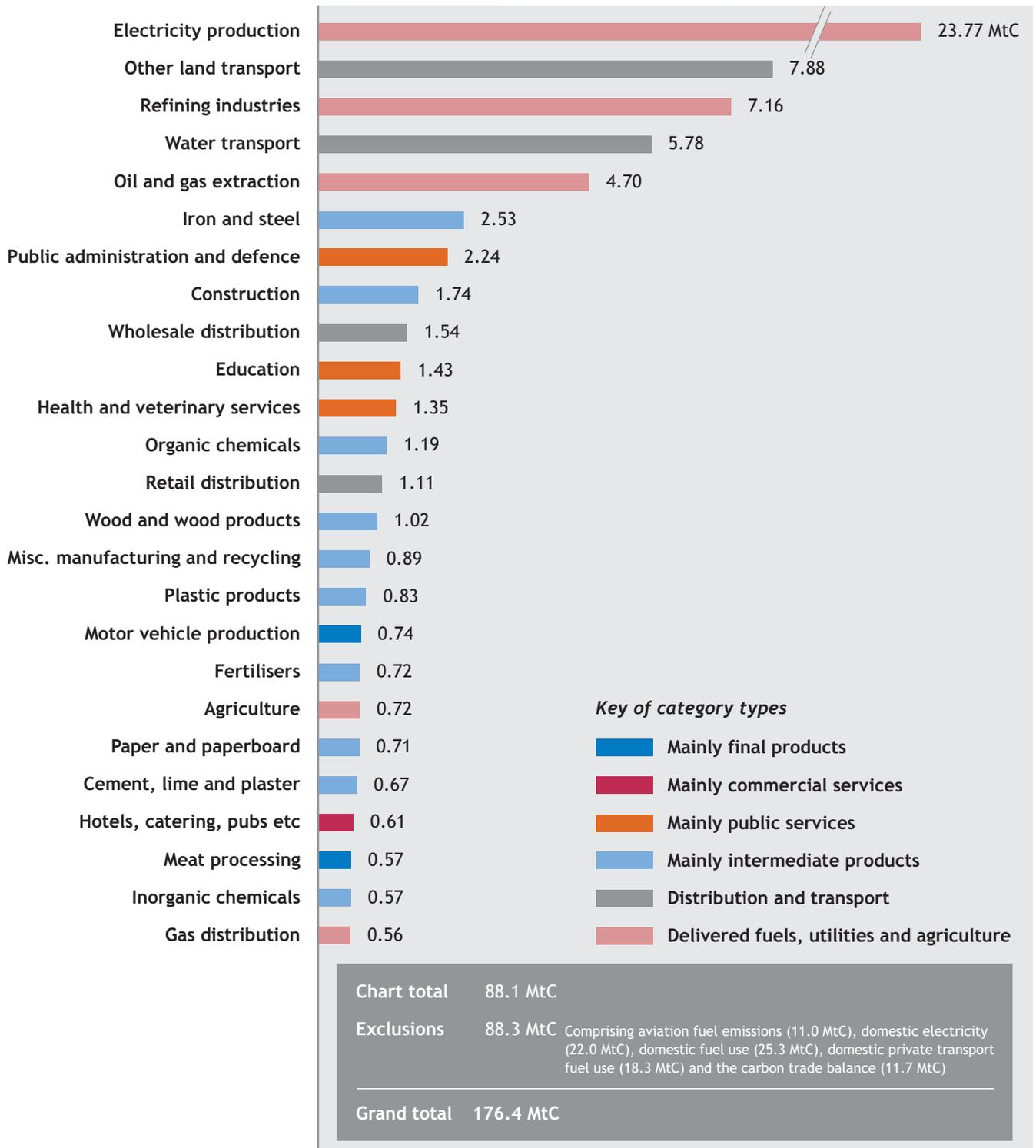
Chart A shows the conventional production-based view of carbon emissions, measured in million tonnes of carbon per annum (MtC).

This account includes UK emissions associated with the production of exports but excludes the emissions associated with the production of imports for UK consumers.

This account illustrates the following:

- ▶ The single biggest emitting category is Electricity Production. The total for the category amounts to almost 24 MtC which is nearly three times the amount of the second highest category;
- ▶ The Other Land Transport category (comprising road freight, buses and coaches, taxis etc.) and the Refining Industries category have second and third highest emissions at 7.9 MtC and 7.1 MtC respectively; and
- ▶ Water Transport is the fourth biggest source of carbon at 5.8 MtC. This can be explained by the reliance on water transport for the international shipment of most primary and intermediary products; and
- ▶ Oil and Gas Extraction and the primary manufacturing categories also show large emissions, specifically iron and steel as well as other intermediary products such as, fertilisers, chemicals, plastics, paper and wood; and
- ▶ The categories relating to the provision of final products and services to the consumer all have emissions of less than 2 MtC.

Chart A: Production-based Account (top 25 categories)



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

▶ B. Consumption-based Account

Chart B illustrates the impact of attributing carbon emissions to categories of final demand. The model has now allocated to each product and service category all the carbon 'induced' directly and indirectly both in the UK and overseas as a result of the demand for that product or service in the UK.

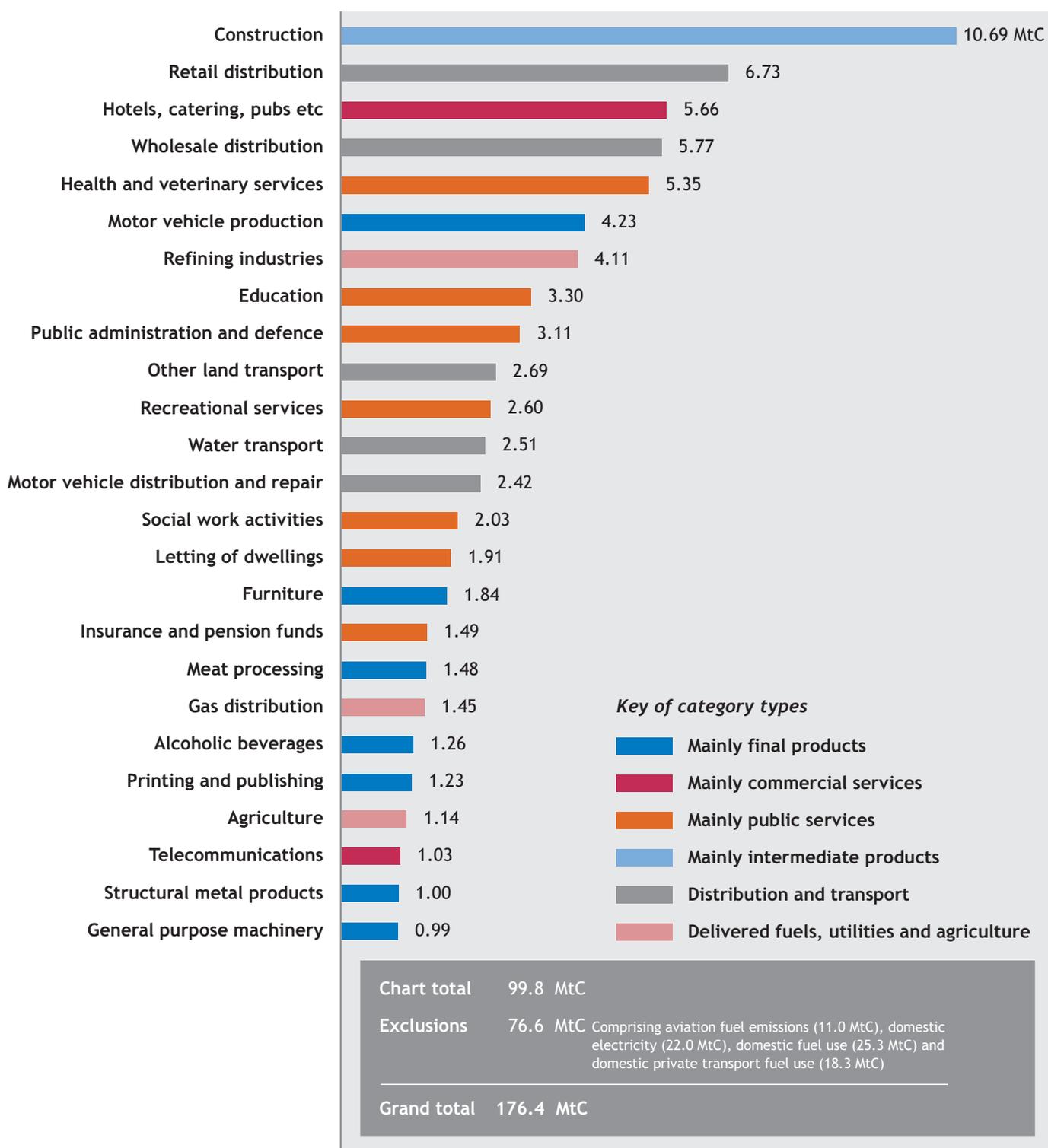
For example, carbon emissions associated with the Electricity Production category and Iron and Steel category have been reallocated to other categories further down the supply chain.

This account now includes emissions from UK imports and excludes emissions from UK exports.

This analysis of Account B illustrates that:

- ▶ Primary manufacturing categories are no longer significant in their own right, as emissions from those categories have been reallocated to final product and service categories;
- ▶ The highest carbon emissions are now associated with the Construction category. This is driven by the high carbon footprint of building materials;
- ▶ Many of the service categories have moved up the scale, especially the Distribution categories, Hotels and Catering, and Health and Veterinary services categories. This can be explained mainly by the significant infrastructure and space heating needs of these categories; and
- ▶ Motor Vehicle Production is the highest "final product" category. This reflects the size of the industry and the scale of carbon intensive materials and intermediate products used in vehicle manufacturing.

Chart B: Consumption-based Account (top 25 categories)



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

▶ C. Consumption-based Account with Fixed-capital Reallocated

Total UK consumption, as shown in Account B, can be split into three groups:

- ▶ Private expenditure (for household consumption);
- ▶ Public expenditure (for public services etc.); and
- ▶ Fixed capital investment.

Fixed capital investment is required to support current and future consumption activities across the first two groups. This investment is typically in construction and refurbishment of buildings, plant, equipment or other capital assets. As such, it is instrumental in the creation of products and services delivered to the end consumer (either as products and services from the private sector or as services from the government).

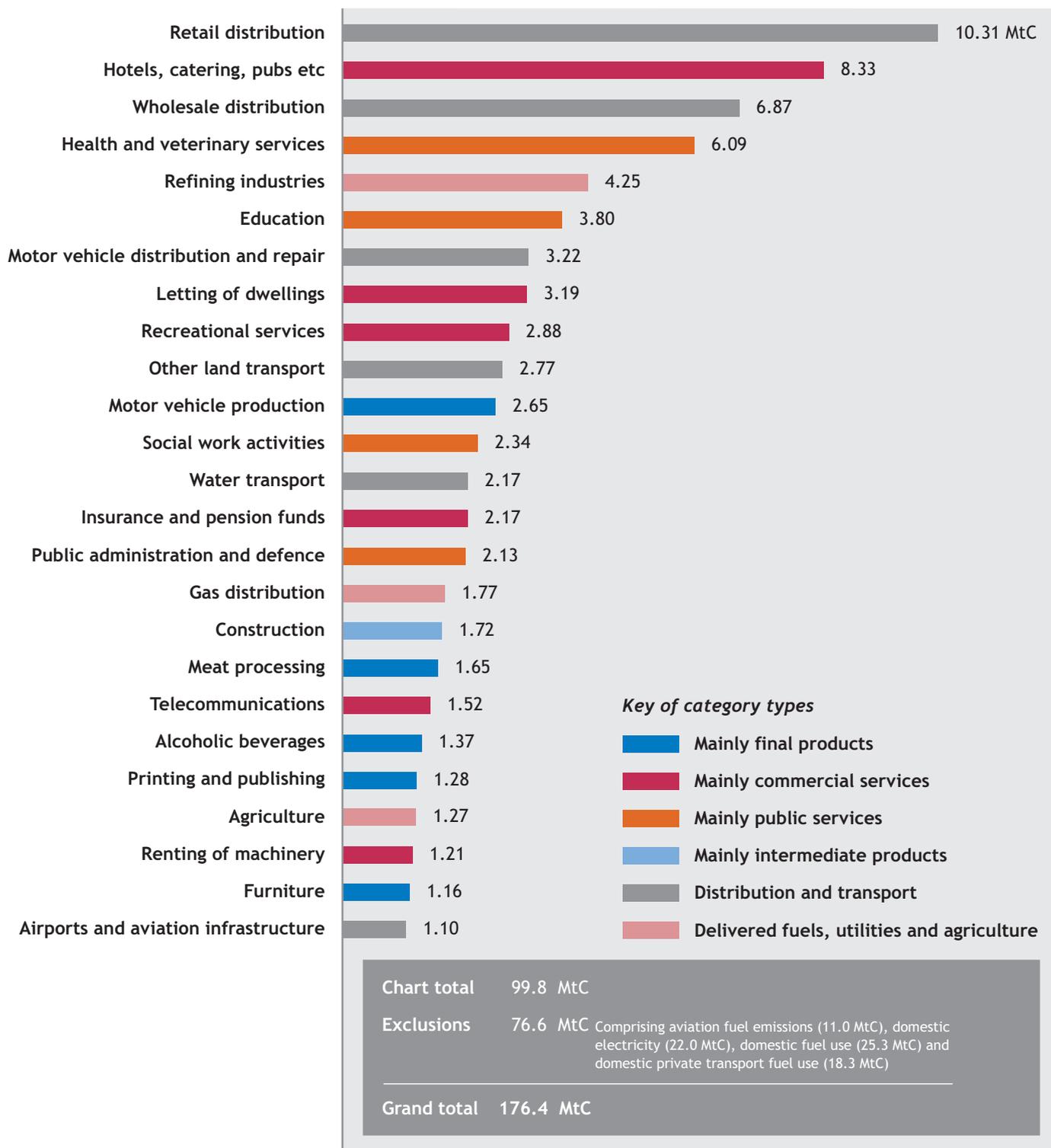
Fixed capital investment expenditure is made in the Construction category, and makes up a portion of Motor Vehicles, Water Transport and Furniture categories. In essence, the outputs from these categories relate to the fixed capital investment in other categories. Carbon emissions from these fixed capital investments can be reallocated as part of the process to reallocate all the supply chain emissions to the product and service categories that they support.

In this account, fixed capital investment data are taken from the ONS 2002 Blue Book National Accounts. The emissions from fixed capital investment amounts calculated in Account B are then allocated against each of the 122 production categories. The emissions associated with fixed capital investment from each production category are then reclassified into the consumption categories in a process similar to that in Account B. This gives a measure of the effect of the emissions from fixed capital investment in the supply chain on the final products and services.

This account provides the following insights:

- ▶ The construction category now occupies a much lower place in the rank order since most of its outputs are directed towards fixed capital investment in other categories;
- ▶ Similar to Account B, the distribution categories maintain a high position on the chart along with Motor Vehicle Production and a variety of service categories which demand significant infrastructure;
- ▶ In the main, service categories (red and orange) and distribution and transport (grey) dominate the top ranking places in the chart; and
- ▶ Intermediate product categories (light blue) no longer appear in the top 25 as their emissions have now been reallocated elsewhere.

Chart C: Consumption-based Account with Fixed-capital Reallocated (top 25 categories)



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

▶ D. Consumption-based Account with Fixed-capital and Distribution Reallocated

There are three significant distribution categories: retail distribution, wholesale distribution and motor vehicle distribution. Account C shows that the carbon associated with each of the three categories is large. Indeed, retail distribution is the largest category in Account C once fixed capital investment is reallocated.

The distribution categories in Account C cover:

- ▶ The carbon emissions from the fixed investment in buildings and other infrastructure in the distribution categories;
- ▶ The variable emissions, mainly from electricity and fuel use in those buildings; and
- ▶ The fuel emissions associated with distributing goods around the economy.

From a functional use perspective, the distribution categories deliver the final products and services to consumers. It makes sense, therefore, to reallocate the carbon associated with the distribution categories to their associated product and service categories.

In this account, the carbon associated with the three distribution categories is allocated to product and service categories on a pro-rata basis using the distribution and retail margins data reported in the 2002 UK Final Consumer Expenditure Accounts from ONS. The carbon emissions from the distribution categories are reallocated across all the other categories in proportion to the reported distribution margins.

The results of the reallocation are shown in Chart D. The following conclusions are clear:

- ▶ The Retail, Wholesale and Motor Vehicle Distribution categories no longer appear as they have been reallocated to the final product and service categories. Most other categories are left unchanged;

- ▶ Hotels, Catering, Pubs etc is now the largest category with emissions of 8.3 MtC;
- ▶ The Motor Vehicle Production category shows an increase to 7.1 MtC because Motor Vehicle Distribution emissions are now allocated to this category; and
- ▶ The Refining Industries category shows a slight increase to 4.5 MtC now that the emissions from distributing fuel products have been reallocated to this category.

Summary of Accounts A to D

Through the process of defining consumption categories and then reallocating the carbon emissions associated with fixed capital formation and distribution, the model progressively calculates emissions embodied in the delivery of final goods and services, rather than primary manufacturing, distribution or investment categories.

The reallocation of emissions from intermediate inputs to consumption outputs is illustrated by the changes in colour-coded categories from A to D.

In the Production-based Account (Account A), the highest emitting categories are mainly primary resource extraction and processing (pink) or primary manufacturing categories (light blue).

In Account D, carbon is allocated mainly to categories which deliver final products (dark blue) and services (red and orange) directly to consumers. This reallocation reflects the progressive attempt to attribute carbon on the basis of the consumer demand for final products and services.

Chart D: Consumption-based Account with Fixed-capital and Distribution Reallocated (top 25 categories)



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

2.2 Functional use and consumer needs

The ultimate goal of products and services delivered to the consumer is to meet a variety of consumer needs, such as food and catering, space heating and recreation and leisure.

The reallocation from the consumption categories in Account D to consumer needs is a two-stage process:

- ▶ Firstly, a reallocation of emissions from the categories in Account D to domestic functional use categories. This is shown in Account E; and
- ▶ Secondly, a reallocation of the Account E categories into high-level consumer needs categories. This is shown in Account F.

To give a clearer picture of total consumption by the end consumer, these accounts include all household emissions. They include emissions from delivered fuels, from the generation of electricity used in the home and from fuel use in private transport.

The total carbon footprint in Accounts E and F amount to 165.4 MtC. Again it should be noted that aviation fuel emissions are excluded in these accounts. This figure is different from the 2002 UK production carbon footprint published in the Defra e-Digest⁶, primarily because of the difference between emissions from UK production and from UK consumption. A reconciliation is shown in section 2.3.

▶ E. Domestic Functional Use Account

This is the first stage of the reallocation from the consumption categories in Account D to domestic functional use categories. The functional use categories are derived using the standard classification taxonomy *Classification Of Individual Commodities by Purpose* (COICOP) produced by the UN Economic Statistics and Classifications Section. This splits overall consumer emissions into categories such as Household Appliances, Food and Non-Alcoholic Drink, and Recreation and Entertainment.

The model reallocates carbon emissions to each of these domestic functional use categories. This account also includes emissions from fuels and electricity used directly by households for space heating, water heating, lights and appliances.

The model differentiates between the different types of emissions from different stages in the supply chain. These are highlighted with different colour coding on Chart E below. The six key supply chain emission types are: electricity use, direct fossil fuel consumption, transport, utilities (water and waste services, excluding power), final products and final services.

This perspective starts to show the impacts of different consumer needs and purchasing decisions on carbon emissions across the economy. It highlights the high levels of carbon emissions from use of electricity and fuels in the home and from transport. In particular, space heating and water heating are significant sources of carbon emissions. Food and drink and recreation activities are also significant carbon emitters.

⁶ Defra 2005 e-Digest Table 5: Estimated emissions of carbon dioxide (CO₂) by UNECE source category, type of fuel and end user: 1970-2003
<http://www.defra.gov.uk/environment/statistics/globalatmos/download/xls/gatb05.xls>

Chart E: Domestic Functional Use Account



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

⁷ The Housing category includes emissions from the building, operation and maintenance of the building fabric, furnishings and fittings.

▶ F. High-level Consumer Needs Account

In the final stage of the analysis, the model attributes the carbon emissions from functional use categories shown in Account E to high-level consumer needs categories. The high-level consumer needs categories describe broad areas that cover all aspects of the needs of the consumer. Categories include Food and Catering, Commuting, and Hygiene and Health. These are drawn in part from the COICOP classification, with some additional reallocation to aid presentation.

Emissions from each of the functional use categories in Account E are attributed to the high-level consumer needs categories. Some of the functional use categories span more than one consumer needs category. In those cases, carbon emissions are split across the different consumer needs categories. For example, emissions related to the use of delivered fuels in households have been reallocated across the following different consumer needs:

- ▶ Food and catering, for example in cooking and cold appliances;
- ▶ Space heating;
- ▶ Health and hygiene, for example in water heating for showers; and
- ▶ Clothing and footwear, for example in care of clothes using wet appliances.

A matrix table showing how the reallocation takes place is shown in the appendix. Direct and indirect travel-related emissions have been reallocated to functional need categories using data on travel by journey type⁸.

The outcome, as shown in Chart F, shows that it is possible to tie all the upstream supply chain emissions to the fulfilment of these high-level consumer needs. It is possible to say that the process of meeting these high-level consumer needs is what drives all the emissions in the economy.

Some of the underlying domestic functional use category information has been retained to allow each category to be split into direct, indirect and travel-related carbon. The chart is colour coded to illustrate this split. Travel-related carbon emissions include both direct emissions (motor fuels) and indirect emissions (public transport and provision of motor vehicles).

Chart F can be used to draw some general conclusions:

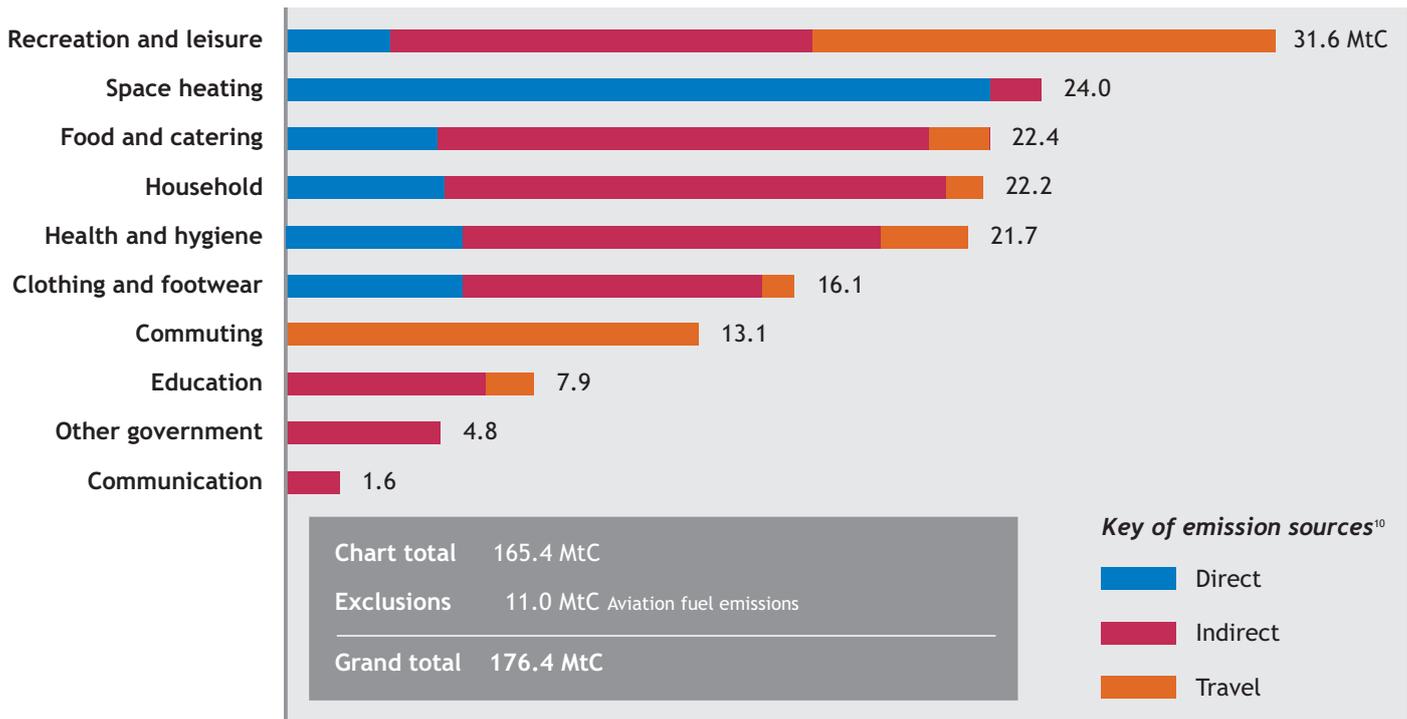
- ▶ The total carbon emissions amount to 165.4 MtC. Again it should be noted that aviation fuel emissions are excluded. This figure is different from the 2002 UK production carbon footprint published in the Defra e-Digest⁹, primarily because of the difference between emissions from UK production and from UK consumption. A reconciliation is shown in section 2.3;
- ▶ The supply chains associated with recreation and leisure have the highest emissions at 31.6 MtC. Just under half of this is travel-related emissions; and
- ▶ This is followed by space heating of homes with 24.0 MtC and food and catering at 22.4 MtC. The majority of space heating emissions occur directly in the home, whereas two thirds of carbon emissions from food and catering are embodied in the products consumed.

The Household category (comprising the materials and energy required to maintain both buildings and furnishings) and Health and Hygiene category also make significant contributions. In the Household category, this is mainly due to the carbon emissions in the production of building materials. In the Health and Hygiene category direct emissions such as water heating make up a significant proportion of the emissions.

⁸ Department for Transport 2004. National Travel Survey, London: HMSO. Available on the web at http://www.dft.gov.uk/stellent/groups/dft_control/documents/contentservertemplate/dft_index.hcst?n=14133&l=4

⁹ Defra 2005 e-Digest Table 5: Estimated emissions of carbon dioxide (CO₂) by UNECE source category, type of fuel and end user: 1970-2003 <http://www.defra.gov.uk/environment/statistics/globalatmos/download/xls/gatb05.xls>

Chart F: High-level Consumer Needs Account



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

¹⁰ Direct emissions are the emissions associated with the direct consumption of (non-transport related) fossil fuels and electricity in the household. Indirect emissions include the emissions embodied in other goods and services, including energy required to produce the goods and services and the emissions from space heating and lighting by the service and government sectors. Travel-related emissions include emissions from transport fuels and the indirect emissions embodied in transport goods and services.

2.3 Reconciliation of production and consumption

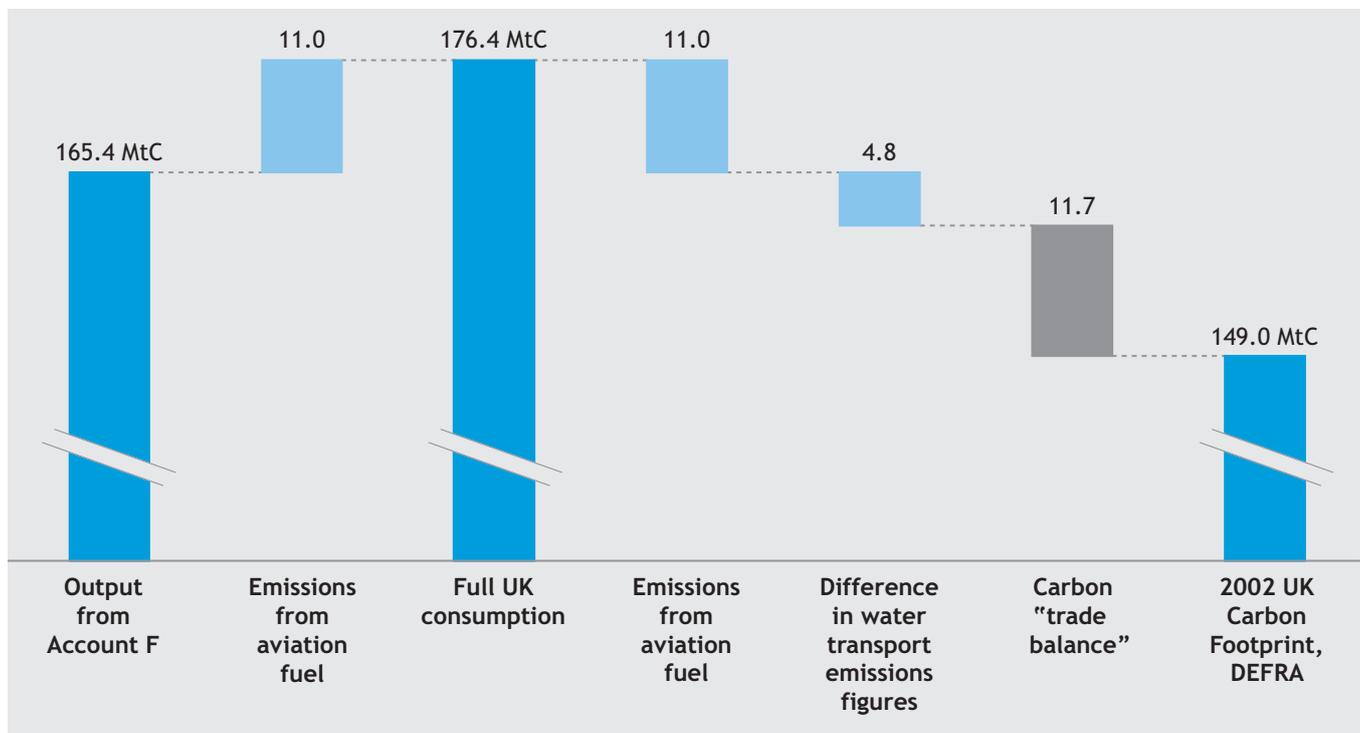
Accounts E and F show that UK consumption emissions are 165.4 MtC. Throughout the analysis, emissions from aviation fuel use (estimated at 11.0 MtC from UK Environmental Accounts energy data) have been excluded. Adding these in gives total carbon emissions from UK consumption of 176.4 MtC.

This figure shows a difference of 27.4 MtC from the 149.0 MtC 2002 UK carbon footprint published in the Defra e-Digest¹¹. This difference is due to:

- ▶ The Defra figures exclude emissions from all aviation fuel use of 11.0 MtC;
- ▶ The Defra figures assume lower water transport emissions of 1.0 MtC against 5.8 MtC in these accounts; and
- ▶ The Defra figures are based on UK production whereas this analysis estimates the carbon emissions attributable to UK consumption. The remaining difference of 11.7 MtC is the estimated carbon “trade balance”. In essence, the positive difference between the carbon footprint of UK imports versus UK exports.

This is summarised in Chart G below.

Chart G: Production versus consumption: Reconciliation with Defra



Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

¹¹ Defra 2005 e-Digest Table 5: Estimated emissions of carbon dioxide (CO₂) by UNECE source category, type of fuel and end user: 1970-2003
<http://www.defra.gov.uk/environment/statistics/globalatmos/download/xls/gatb05.xls>

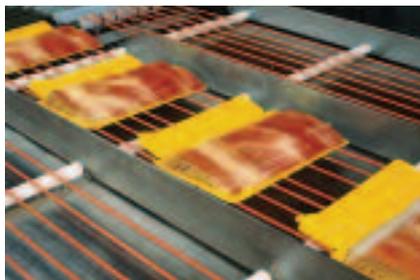
3 Conclusion

The consumption-based approach to analysing carbon emissions provides a powerful new perspective to the existing evidence base for carbon management and policy intervention. Whilst production-based analysis remains an important tool to understand and manage the carbon impact within national boundaries, it is consumption activity and consumer behaviour that drives carbon emissions on a wider scale. In order to meet the long-term emission reduction targets it will be necessary to change current patterns of consumption and the way in which products and services are produced for the final consumer.

Intervention to change consumption patterns is challenging. Effective intervention requires a variety of actors to work together over time, in particular

government and business. Cooperation is also essential at international level in view of increasingly global product supply chains and the growing interdependencies of economies. A combination of measures and policy tools needs to be implemented to provide the right environment for change. These have to be targeted at all life cycle stages and to all major stakeholders. Fundamental changes in consumer behaviour, the structure of supply chains, business models and in physical infrastructure may be needed for long-term success.

Overall, the consumption-based approach to analysing carbon emissions has the potential to be a powerful tool for both government and business in the drive to a low carbon economy.



4 Appendix

Reallocation to consumer need

The table shows how domestic functional use categories are reallocated from Account E to the high-level consumer use categories in Account F.

		Account F: high-level consumer needs										MtC	
		Household	Recreation and leisure	Space heating	Food and catering	Commuting	Health and hygiene	Clothing and footwear	Education	Communication	Other government		Total
Account E: Domestic functional needs	Space heating			100%								100%	22.58
	Private transport	3.2%	40.9%		5.5%	35.9%	7.3%	2.8%	4.3%			100%	18.26
	Transport services (indirect)	3.2%	40.9%		5.5%	35.9%	7.3%	2.8%	4.3%			100%	18.15
	Food and non-alcoholic drink				100%							100%	14.47
	Health and hygiene						100%					100%	11.39
	Water heating						50%	50%				100%	9.07
	Recreation and entertainment		100%									100%	7.61
	Financial and other services	100%										100%	7.00
	Other personal effects							100%				100%	5.56
	Education								100%			100%	5.32
	Housing	100%										100%	5.05
	Public admin and defence									100%		100%	4.81
	Household appliances	25%	25%		25%		12.5%	12.5%				100%	4.26
	Electricity (lighting)	100%										100%	3.42
	Electricity (brown goods)		100%									100%	3.33
	Electricity (cold appliances)				100%							100%	3.11
	Holidays		100%									100%	2.97
	Furnishings and other household	100%										100%	2.92
	Clothing and footwear							100%				100%	2.65
	Electricity (wet appliances)						50%	50%				100%	2.37
	Delivered fuels (indirect)			75%			12.5%	12.5%				100%	1.94
	Cooking				100%							100%	1.78
	Alcohol and tobacco		100%									100%	1.73
	Electricity (misc)	100%										100%	1.63
	Post and communication									100%		100%	1.56
	Water supply and misc services						75%	25%				100%	1.51
Books and newspaper								100%			100%	1.01	
MtC		22.24	31.59	24.03	22.42	13.09	21.69	16.11	7.89	1.56	4.81	165.43	

Source: UK Carbon Attribution Model, Centre for Environmental Strategy, University of Surrey, 2005

www.thecarbontrust.co.uk
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