8 Overall Results

8.1 Introduction

This chapter brings together the results from each of the other chapters into an integrated and freestanding Main Report on the whole project. It aims to condense a large body of evidence into a format where the implications can be clearly seen, referring to the rest of the Technical Report for further information. In each section there are summary points in shaded areas: these are available in a separate 'Executive Summary' document.

The main thrust of this chapter keeps coming back to the central question:

> *How to achieve the Factor Four levels of reduction in ecological footprint, to move the region towards environmental sustainability?*

The now conventional answer to this is to halve resource use, while doubling resource efficiency.[1] In practice most of the trends are going in the opposite direction – resource use being closely tied to economic growth: the implication is that the resource usage which we are aiming to halve, is projected to triple in size by 2050. In other words, the scale of the challenge is huge, and this report can only aim to open up the agenda.

As is typical in such developmental research, the writing of a summary of a large set of technical chapters then evolves into a report in its own right. The task of bringing each of the technical chapters together into a common format focused on the implications for policy, business and lifestyles – the 'so what' questions. The result is not the final answer or a complete analysis, but a significant body of evidence to take forward in further strategic action and research.

Structure of this chapter

In Section 1, we provide an overview of the framework and methodology for the regional accounts and the analysis of data. There are some interesting questions on boundaries, the nature of consumption, and the interaction of production and consumption.

In Section 2, we present the aggregated baseline (2000) results for the regional MFA-EF. This involves a calculation of total material flow, direct and indirect; total energy, CO_2 and land requirement; and the total ecological footprint.

In the following sections 3–9, the main body of this report, the results for each consumption sector are presented in a more or less common format. This starts with an executive summary in shaded boxes. Then there is a review of the material flow (MFA), in common units and then also in terms of the CN classification of material types.

There follows in each consumption sector a review of the current policy situation, and current trends and driving forces of change. The 'scenario settings' contains a summary of the key driving forces which can be input into the scenario model. This points to a set of alternative scenarios which shows how each of the consumption sectors is a complex and rapidly changing picture. The more detailed focus on the Factor

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[1] von Weizsacker, E, Lovins, A & Lovins, L.H, 1997: *'Factor Four: Doubling Wealth, Halving Resource Use'* : London, Earthscan

Four scenario explores the implications of meeting the F-4 goals, which need to be seen in context of social and economic change.

The outcome in each consumption sector is to point towards the implications for strategy and action for different parties: policy at various levels, businesses, third sector (non-profit) organisations, consumers and communities.

A final review in section 10 points out the implications for the next steps.

In each chapter the main points are shown in shaded boxes at the beginning, for easy reference. The more detailed summary tables and other information are presented in the technical report Chapters 3–7, and in the Appendix.

8.1.1 Format for results

Classification of sectors

The category titles for the MFA-EF analysis aim to make clear what is 'manufacturing' and what is 'services' (this includes construction and transport).

This reflects a structural perspective on different interactions between material resources (MFA) and human resources. It builds on the recently developed practical framework of EF functional or 'consumption sectors': Shelter, Food, Transport etc. It then shifts this classification towards a more conventional economic structure approach, in order to provide a more comprehensive logic for the classification of material flows:

- **Primary production**: production/extraction of materials/commodities.
- **Secondary production**: manufacturing/processing of materials into 'products'.
- **Factors of production**: (i.e. in the economic sense, factors which facilitate production), particularly construction and transport/distribution.
- **Services (tertiary) production**: services sectors (commercial and public) where material/products are secondary to the human activity which may distribute or enhance them, but where they are not generally the main item of significance or 'added value'. These **production** services are inter-industry or intermediate services for other businesses, as distinct from the **consumption** services below.
- **Services (tertiary) consumption** (commercial and public): these are services delivered to the final consumer (households), where the consumption of materials/ energy is instrumental to that end.
- **Household consumption,** in economic terms, 'final demand' to households: this category may be more appropriate for the activities which are clearly focused on the point of final demand: e.g. passenger transport.
- **Residuary**: waste production and pollution control: the EF here can be based on the cumulative environmental impacts of the disposal method; it will also be possible to add in the calculation for the resources or 'material lost' if this is not accounted for elsewhere.

One example is the ***food and agriculture*** sector: in this sector at least it is fairly clear what is meant by 'consumption', in comparison to some other sectors.

- ***Primary*** food growing
- ***Secondary*** food processing, packing, manufacture
- ***Factors:*** Land, buildings, transport etc, for the food chain
- ***Services*** related to the food supply chain: insurance, advertising, etc

Each of these is involved in **consumption** of food by a) direct by households b) in commercial catering and c) in public sector catering.

As far as possible the data sheets aim to distinguish these different stages. However at present there is still a large difference in classification between the datasets on production, and those on consumption. Therefore at this stage the method and the MFA results do not claim to be comprehensive and definitive.

Data classifications

The data structure used in this MFA-EF study includes the Combined Nomenclature (CN) list of commodities[2] (*materials and products*). It is also arranged around a framework of economic activities which is related to the standard SIC format, and aims to make clear what is 'manufacturing' and what is 'services' (*activity categories*). As the work develops in further projects, this will enable a shift of all data towards the more comprehensive framework of a Physical-Input-Output-Table (PIOT).

The proposed composite codes and *activity category* titles and subtitles are shown in Table 8.1.1; they act as headings in the result tables of all MFA and EF calculations.

Table 8.1.1 Activity categories for the presentation of MFA and EF results following the SIC classification (result table headings)

- **0: Food & Agriculture**
  - Food and drink consumption in households
  - Food and drink consumption in restaurants/other catering
- **1: Energy & Water (utilities)**
  - Energy and water consumption in households
  - Energy and water consumption in the commercial sector
- **(2: Manufacturing Industrial Goods:** *this does not appear, as it is assumed as production impacts which are embedded in the other consumption sectors)*
- **3: Manufacturing: Durable Goods**
  - Households: cars
  - Households: furniture and floor coverings
  - Households: electrical equipment
  - Commercial sector: electrical equipment

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[2] The Combined Nomenclature (CN) classification is required in order to be compatible with other studies coordinated by the Mass Balance UK / Forum for the Future (http://www.massbalance.org)

- **4: Manufacturing: Consumable Goods** *(defined as products with average life of less than 1 year)*
  - Household consumables
- **5: Construction**
  - Aggregates and construction materials
- **6: Consumer Services (Commercial Services)**
- **7: Transport Services**
  - Passenger Transport
  - Freight Transport
- **(8: Business Services:** *this is not shown as it is assumed to be embedded in the consumer services account)*
- **9: Public Services (Public Administration, i.e. government and local authority offices):** *(at present there is no data for health, education, defence etc, so this section is an interim account)*
- **Built Land** *(this is included for its small but significant effect on the EF calculation only)*

Activity categories represent the headings whereas *materials and products* (CN codes) are represented in columns (see Table A.5.1 in the Appendix). The whole result table would be too large, however, to be printed on A4 sheets. For this reason only those parts of the result tables that actually contain numbers are presented in the following sections. Definitions for the *activity categories* are given in Section 8.2 that also includes all results for material consumption, CO_2 emissions and Ecological Footprints in the South East.

Direct and total material consumption

The whole methodology of this study is based on consumption (rather than production) of households and the commercial sector. For this reason MFA results are presented in two different ways, as Direct Material Consumption (DMC) and Total Material Consumption (TMC), definitions of which are given below.

DMC (**Direct Material Consumption**) is defined as the total amount of materials directly used in a national economy (i.e. excluding indirect flows) and consumed by domestic actors (i.e. exports are subtracted)[3]. DMC is defined in the same way as other key physical indicators such as gross inland energy consumption[4]. DMC equals domestic used extraction plus imports minus exports (or more simply DMI minus exports):

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3 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

4 Energy balances by the International Energy Agency (IEA) use the term “Primary Energy Supply” whereas the Eurostat energy balances use the term “Gross Inland Energy Consumption”.

+ domestic extraction used (DE)

+ (physical) imports

= Direct Material Input (DMI)

_ (physical) exports

= Direct Material Consumption (DMC)

TMC (**Total Material Consumption**) is defined as the total (life-cycle-wide) material use associated with the domestic consumption activities, including indirect flows imported but minus exports and associated indirect flows. TMC equals TMR (Total Material Requirement) minus exports and their associated indirect flows:

+ domestic extraction used (DE)

+ (physical) imports

= Direct Material Input (DMI)

+ unused domestic extraction

+ indirect flows associated to imports

= Total Material Requirement (TMR)

_ (physical) exports

_ indirect flows associated to exports

= Total Material Consumption (TMC)

To form these indicators the materials used by the economy are added together in terms of mass, and hence do not take any account of the relative impacts on the environment that different materials will have. This is a new group of indicators, which meets the commitment given in QOLC (reference indicator A1) to develop a general indicator of UK resource use.

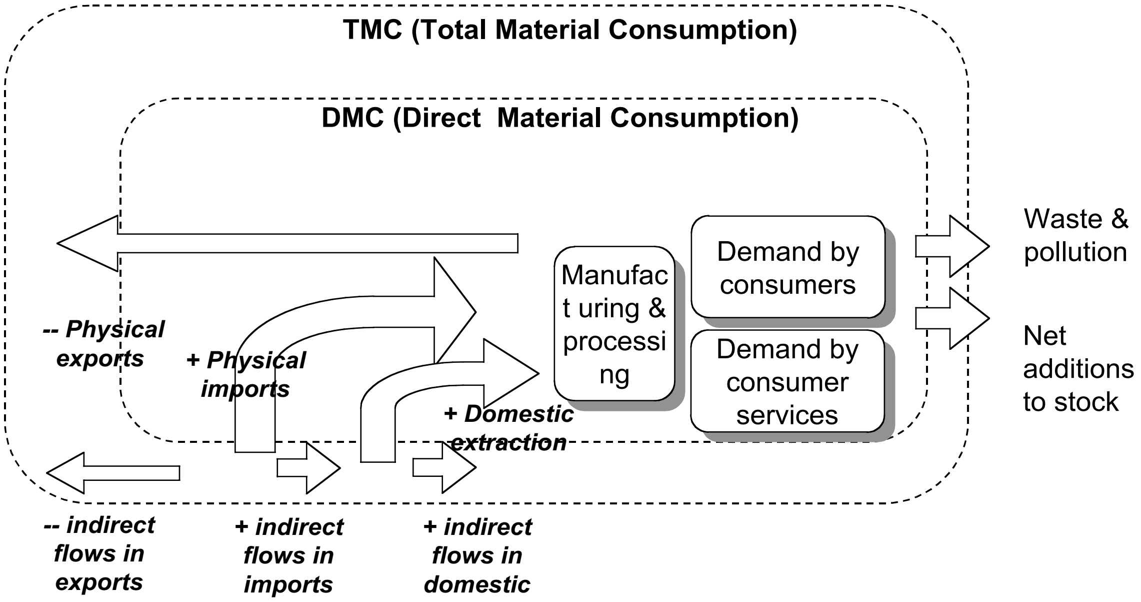

Figure 8.1 Mapping Direct Material Consumption and Total Material Consumption

Classifications and double counting

There are ongoing questions for Ecological Footprint methodology, on the allocation of consumption and impact between different sectors. These are complicated by the inevitable differences in classification between ***economic*** sectors (SIC/NACE codes), ***material*** types (CN classification), ***product*** types (PRODCOM), and any number of sectoral systems (e.g. the CI/SfB construction system). At the time of writing, international negotiation is under way on a standard methodology and classification format for the Ecological Footprint. Until this is decided, the results here are presented as interim work in progress.

The practical implication is that the EF factors are relatively well defined for sectors of direct consumption e.g. retail purchases by households; less well defined for sectors involved with indirect consumption; and not well defined for public services sectors, including health, education, defence, security and other state functions.

There are also questions on double counting which need to be made clear. The implication is that some of the accounts in the following pages are 'satellite' accounts, i.e. more detailed components which are not to be added to the total.

Table 8.1.2 (a) Addressing double counting in the MFA approach

0: Food & Agriculture		1: Energy & Water		3: Man. Durables		
Food & Drink, Households	Food & Drink, Restaurants	Households	Commercial Sector	HH Cars	HH Furniture, Floor Cov.	HH Electrical Equipm.[a)]
Transportation and packaging worked out separately → Chapter 3.4	Transportation and packaging worked out separately → Chapter 3.4	no double counting issue	no double counting issue	CO_2 emissions & EF of manufact & maintenance of cars are included in the Passenger Transport category (7: Transport Services)	no double counting issue	no double counting issue
Transportation and packaging included in the final EF number	Transportation and packaging included in the final EF number					

a) MFA of electrical equipment has been worked out separately (see Chapter 3.7) but has not been included in the final EF number.

Table 8.1.2 (b) Addressing double counting in the MFA approach

4: Man. Consum.	5:Construc. Services	6:Consumer Services	7:Transport Services		9: Public Services	Built Land	Waste
HH Consu-mables	Construction Materials	Commercial Services	Passenger Transport	Freight Transport	Public Admin.		
Packaging worked out separately → Chapter 3.6	Intermediates subtracted; transportation worked out separately → Chapter 3.5	Car use for business purposes included in passenger transport	EF Includes CO_2 emissions of manufacture and maintenance of cars	Includes all Freight Transport relevant to the SE	Car use for public admin purposes included in passenger transport	Road space is allocated to cars in the passenger transport component	EF of waste is seen as 'satellite account'
Packaging included in the final EF number	Intermediates not included; transportation included in the final EF number		EF includes (non-transport related) built land area			All other built land is included in this section	Not included in the final EF

Format of results

The tables and discussion of results in the following sections are arranged around the framework above, i.e:

- Material flow analysis (MFA) in terms of direct material consumption: (DMC).
- Material flow analysis (MFA) in terms of total material consumption: (TMC), this includes the indirect, unused or wasted proportion of a material flow.

- CO_2 emissions: this is calculated in terms of actual emissions from activity within the TMC boundary above, including all relevant stages in a product supply chain, i.e. extraction, manufacturing, processing, distribution and consumption.
- EF (ecological footprint): this is calculated from the CO_2 emissions above, added to any other greenhouse gases involved, this forms ‘energy land EF’; factoring in any physical land use (as in food production) as ‘real land EF’ produces a total EF.

There follows in each section a table based on the CN material classification system. This provides the nearest equivalent to a scientific ‘mass balance’.

There follows in each section, a ‘scenario settings’ table. This is arranged around a small number of key indicators for driving forces which may be quantified as inputs to the scenario model /database. It is also arranged around the four ‘footprint’ scenarios identified in Chapter 7 as a representative spread of policy aspirations and possibilities.

8.1.2 Issues in the MFA–EF method

System boundaries

While ecological footprinting is an excellent method for communicating total environmental impact, it has limitations and some unresolved questions. As discussed in the literature, these include:

- Aggregation of environmental impacts to one common measure: this is both a strength in communications, and a weakness in analytic power.
- Simplification of complex life-cycle effects.
- Omission of most inter-industry trading: i.e. when one industry makes products for another industry.
- Focus on consumption via the ‘responsibility’ principle, rather than production activities on the ‘locality’ principle. This means that many environmental initiatives in the South East region might not show up on the EF accounts.
- There are further issues concerning the inter-dependency of economic sectors and functional regions as below.

From the ***economic perspective***: the typing of consumption sectors e.g. transport or food, is in a sense artificial, as each sector is inter-dependent on others: the food sector requires transport and vice versa. The economic input-output approach is the standard approach to capturing this inter-dependency, and links from EF to IO methods are being developed in the follow-on to this project.

From the ***social perspective***: the use of footprinting is a valuable input to a wider discussion on quality of life and the social processes which may enhance it. For instance household appliances are generally seen as essential consumer goods, whose footprint may be reduced where it is socially beneficial to share, lease or otherwise reduce direct consumption. This raises interesting questions on the definition of ‘consumption’ – as in the case of a car:

- Direct household consumption (a): e.g. a householder buys a new car from a dealer
- Direct household consumption (b): a householder buys a car second hand from a friend
- Non-accounted consumption: a householder borrows her friend's cars when needed
- Direct commercial consumption: e.g. householder leases a car from a company
- Indirect commercial consumption: e.g. a householder hires taxis for all their journeys
- Intangible commercial consumption: e.g. a householder buys shares in a transport firm

Each of these may involve a similar mix of commercial and physical transactions, yet they might be classified in quite different places in both economic accounts, and environmental accounts.

From the ***policy perspective:*** experience of scenario initiatives such as the NW Futures programme showed that stakeholders are often less interested in the numbers, and more interested in the underlying structural issues: e.g. social exclusion, civil liberties, technological risk and so on. However the numbers can have a strong symbolic value and awareness raising function.

Sectoral and boundary issues

There are particular issues in the application of footprint methodology for each of the key material inputs in the consumption sectors:

- Energy or water: the picture of energy or water ***demand or consumption*** is often quite different to that of energy/water ***production or supply***. The definition of regional boundaries has to be done carefully, so that for instance the effects of regional renewable production will show up against the UK power supply profile.
- Minerals: here the footprint calculation method has to deal with the large accumulation of 'stocks' i.e. fixed infrastructure in the urban system. Is the 'net addition to stock' an input or an output?
- Waste: footprinting of waste arising/disposal depends on the accounting boundaries between resource inputs and waste arisings.

For each of these, the mass balance spreadsheets are being developed to show these other dimensions.

Production vs consumption

A further question is the distinction between two sides of a coin:

- production (the conventional basis for allocating economic activity); and
- consumption (the accepted basis for allocating resource flows and footprint effects to the behaviour of final consumers).

This distinction becomes important and relevant in the case of changes to local/regional improvements to production, processes and the infrastructure which supports them. With current footprint methodology these do not show up in the accounts, as the footprint is calculated solely on consumption with a set of national/world figures.

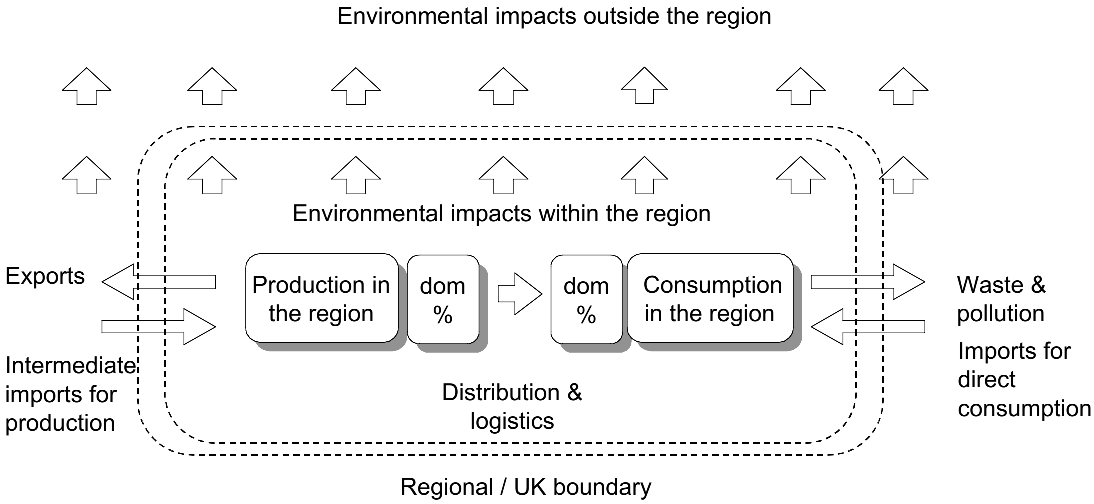

Figure 8.2 Regional environmental accounts (adapted from Ekins 2001)

The diagram above shows a kind of mapping of the environmental effects of both production and consumption. The South East region, being highly globalised and service-driven, might be assumed to have high levels of import and export to/from other UK regions, although data on this is very difficult to find. However there will be, depending on the industry and sector:

- a certain proportion of production (for final demand) which is destined for the region
- a certain proportion of consumption which is sourced from within the region

These proportions become much more important in the light of policy which may seek to re-internalise more of the regional economy. This might be for a combination of economic, social or environmental objectives, of which the latter is obvious.

At present in the South East economy, goods and products are produced and mainly ***exported*** to the UK and the world. A similar set of goods and products are consumed at the point of 'final demand' by households, and mainly ***imported*** from the UK and the world. If the overall footprint of the region is to reduce then an increasing local proportion of production and consumption, in a 'closed loop' cycle, will be part of that picture.

The practical focus of Taking Stock also suggests this integrated approach. Waste arisings which show up on the consumption account, (municipal solid waste) are in fact a small proportion of the total waste arisings from industrial and commercial production within the region. If 'total waste arisings' are then the benchmark for the regional issue of waste management, then production and waste minimisation in industry has to be part of that equation. In other words, for a meaningful picture of regional waste management we have to account for both consumption and production.

In addition it is clear that many of the environmental impacts experienced directly in the region occur on the production side. The diagram below shows the approximate order of direct and indirect environmental impacts generated in different spatial scales: Greater London, the South East region, UK and the world.

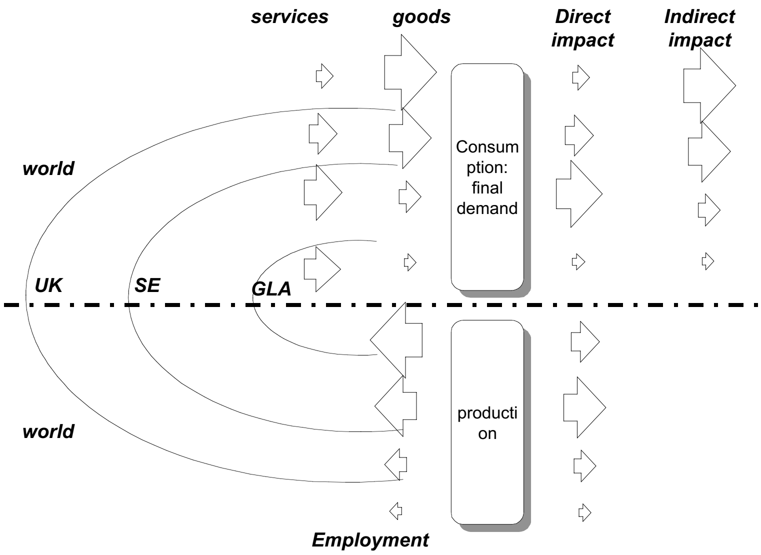

Figure 8.3 Ecological footprint analysis (2): boundaries, production/consumption

Consumption and production profiles

A further insight into the links between production and consumption comes from recent work for the IPCC (Inter-governmental Panel for the scientific assessment of Climate Change) (Dewick, Green and Miozzo 2002). This comes from a structural analysis of the way in which different types of industry combine finance, labour, land, skills and innovation. While the analysis is structured around production sectors, there are potential applications to the counterpart sectors in consumption.

The table below also shows projections of 'business as usual' economic growth and technological innovation, on the anticipated energy demand of both developed and developing countries. The latter are increasingly the source of the raw materials/commodities and standard products in the developed world, and hence the likely trajectories of energy/emissions is of direct interest to any scenarios for EF. In particular this would highlight the distribution of EF between developed and developing nations.

Table 8.1.3 Pavitt (1984)/Soete and Miozzo (1989) classification of industrial sectors

Category of firm		Typical core sector	Net effect on developed countries' Energy Demand**	Net effect on developing countries' Energy Demand**
Supplier Dominated General	SDG	Agriculture Housing, Traditional manufacturing	No change	Increase
Supplier Dominated Services	SDS	Personal services (restaurants, laundry) Public and social services (health, education)	Decrease	Large Increase
Scale Intensive General	SIG	Bulk materials (steel, glass), Assembly (consumer durables, cars)	No change/increase	Increase
Specialised Suppliers General	SSG	Machinery Instruments	Increase	Large Increase
Scale Intensive Physical Networks	SIPN	Transport Wholesale	Increase	Increase
Scale Intensive Information Networks	SIIN	Finance Insurance Communications	Increase	Large Increase
Science Based General	SBG	Pharmaceuticals	Increase	Increase
Specialised Suppliers/Science Based	SS	Software Specialised Business Services	Large Increase	Large Increase

Boundary questions

Boundaries and exports: a further question is on the allocation of final demand into 'exports'. This fraction (% of production) represents the production which is not 'consumed' in terms of final demand, and therefore exported. For regional data there is a problem in distinguishing between exports to other regions in the UK, and exports overseas. A range of assumptions and interpolations are needed (with full transparency).

Clearly boundary issues are crucial in the definition of what is production and 'consumption'. The special case of the South East region with its very large inter-dependence with Greater London deserves close inspection. For instance an affluent resident with an address in the South East region may spend most of their working days and leisure time in London, with weekends in Devon and holidays abroad. The allocation of their 'footprint' then becomes an accounting convention based on residential address, rather than an accurate representation of a physical flow. The distinction becomes important when we try to relate the MFA-EF accounts to local and regional problems, such as waste mountains, air quality or traffic congestion.

Integrated footprint analysis

Given the limitations above there is a need for a more integrated framework which links EF calculations to all relevant production and consumption in a regional economy. The linked database model under development aims to move towards this.

One question is on the allocation of final demand into household and government: i.e. a proportion of material consumption can be allocated to householders, but provision of health, education, security and so on is a more complex issue. Again the use of input-output techniques provides a more comprehensive picture, which distinguishes clearly between demand from households and the public sector. The rationale here follows the economic convention, which is due to the very different organisation of money flow between public and private sectors.

The diagram below shows the basic concept of an integrated production/consumption accounting framework, with the 'imputing' of resource demands by economic sector. This has several benefits:

- Including all footprint effects both direct and indirect, and producing these in the form of 'multipliers': for instance, the total footprint of the construction sector will then include the proportional effects of all the industries which indirectly supply the construction sector.
- Including a total footprint effect for public services ('government demand'): e.g. the health services will be a consumer of buildings, transport etc, and each of these indirect effects are factored into the health multiplier. One question is on the allocation of final demand into household and government. The rationale here follows the economic convention, which is due to the very different organisation of money flow between public and private sectors. A further question is how to account for 'third' sector activities, but this is not within the scope of the current project.

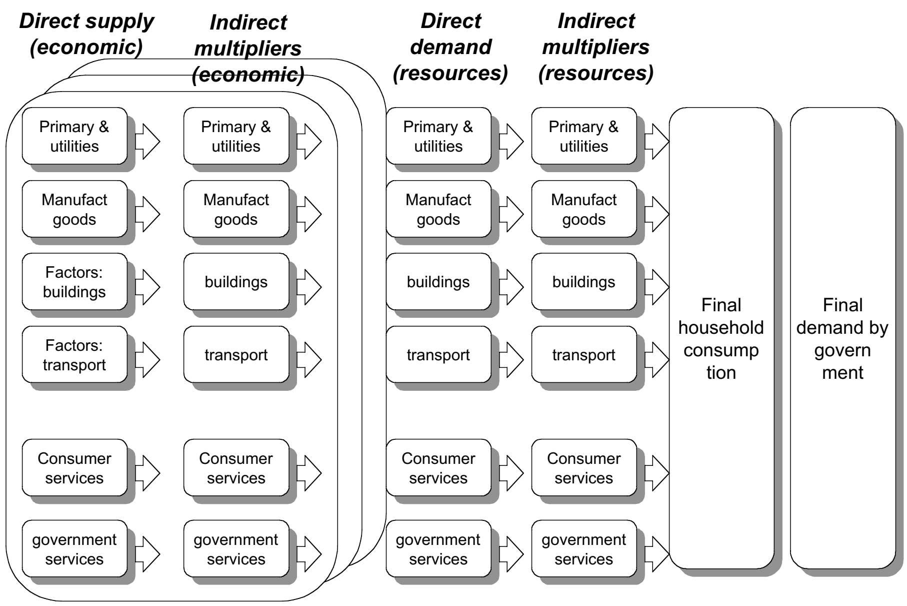

Figure 8.4 Ecological footprint analysis (3)

8.2 Regional MFA and EF Results

In this section the overall results (totals) of the MFA and EF calculations are presented for the South East region in the year 2000. The following section provides a further analysis of the results.

The summary results are deliberately rounded to very few digits. The MFA-EF accounts are estimated to be accurate to within +/- 5%: but the definition of classifications and accounting frameworks is itself uncertain to within +/- 10 or 20% depending on the category.

8.2.1 Summary of results

Material flow and consumption

- The direct material consumption (DMC) for the South East region is 88 million tonnes per year. This equates to **11 tonnes per person**.
- The total material consumption (TMC) (including indirect material flows of imports and domestic production) is 211 million tonnes per year. This equates to **26 tonnes per person**.
- The largest single component of the direct material consumption (DMC) is the construction sector, with 50.5 million tonnes per year of bulk materials.
- The result of the TMC is a total climate change emissions in the form of CO_2, of **158 million tonnes** per year. This equates to **19.5** tonnes per person.

Ecological footprint

- The calculation for ecological footprint (EF) shows a total of **55 million** global hectares (Mgha). This equates to **6.8 global hectares per person.**
- The total EF from all activities is 29 times the physical land area of the region (1.9 million hectares). The total construction footprint area (‘real land’ + ‘energy land’) is 5 times larger than the actual area of the region. (As the name suggests, ‘global hectares per year’ are a notional accounting quantity distributed around the world).
- The largest single component of the total EF is the food/agriculture sector, with 25% of the total.

‘Internalisation: this is an experimental measure, based on the ratio between direct and total material consumption (DMC/TMC):

- The least internalised sectors (i.e. the most intensively manufactured) are the cars and electronic products.
- The most internalised sectors (i.e. where production and consumption have the largest overlap in accounting frame) are the construction and transport sectors.

Production vs consumption

The CO_2 emissions in 'production' (i.e. direct emissions accounted for in the region) are 36% of the CO_2 emissions in consumption. This suggest that two thirds of the physical activity which maintains the affluence of the South East region, takes place elsewhere in the world.

8.2.2 Overall MFA–EF results for the region

Table 8.2.1 and Figure 8.5 (below) show that the biggest impact in terms of DMC, TMC and CO_2 emissions comes from the construction sector. The material requirements of this sector are clearly large (100 Mt of a total 211 Mt TMC); but also energy consumption (embodied as well as direct) is high, and the footprint of the construction sector is the second highest apart from food consumption.

Food production, supply and consumption shows the highest EF and accounts – together with passenger transport – for the second highest CO_2 emissions per capita. However, if both passenger and freight transport are taken together, they account for the highest CO_2 emissions and footprint by far. Nearly 43 million tonnes of CO_2 were released by all transport in the South East in 2000 (5.3 Mt per capita or 27% of all CO_2 emissions in the South East); however the material flows (DMC, TMC) of transport are relatively low, due to the fact that burning of fossil fuels to form CO_2 is nearly 100% of the total material flow.

Table 8.2.1 (part 1) MFA and EF results for consumption of households and the service sector in the South East

	0: Food & Agriculture		1: Energy & Water		3: Man. Durables			
Totals (double counting corrected)	Food & Drink, Households	Food & Drink, Restaurants	Households	Commercial Sector	HH Cars	HH Furniture, Floor Cov.	HH Electrical Equipm.	Units
DMC: Direct material consumption	5.01	0.50	7.54	3.31	0.51	0.39	0.10	(Mt)
TMC: Total material consumption	24	1.9	14	7.59	6.38	2.37	3.83	(Mt)
Total CO_2	24	1.7	18	8.23	a)	1.13	2.10	(Mt)
Total EF	12.52	1.19	4.82	2.13	a)	0.56	0.68	(Mgha)
INTERNALISATION								
Ratio of DMC / TMC	20%	24%	55%	44%	8%	17%	2%	%
MFA-EF PER PERSON								
DMC per capita	0.62	0.06	0.93	0.41	0.06	0.05	0.01	(t/cap)
TMC per capita	3.04	0.25	1.70	0.93	0.79	0.29	0.47	(t/cap)
Total CO_2 per capita	2.94	0.21	2.29	1.01		0.14	0.26	(t/cap)
Total EF per capita	1.54	0.15	0.59	0.26		0.07	0.08	(gha/cap)
PROPORTIONS OF TOTAL								
DMC %	5.7%	0.6%	8.6%	3.8%	0.6%	0.4%	0.1%	%
TMC %	11.7%	1.0%	6.6%	3.6%	3.0%	1.1%	1.8%	
CO_2	15.1%	1.1%	11.8%	5.2%		0.7%	1.3%	
EF%	22.6%	2.2%	8.7%	3.9%		1.0%	1.2%	

a) CO_2 emissions and footprints of cars are included in the Passenger Transport category (**7: Transport Services**)

Table 8.2.1 (part 2) MFA and EF results for consumption of households and the commercial sector in the South East

	4: Man. Consum.	5:Construc. Services	6:Consumer Services	7:Transport Services		9: Public Services	**All Categories**	
Totals (double counting corrected)	HH Consu-mables	Construc-tion Materials	Commercial Services	Passenger Transport	Freight Transport	Public Admin.		Units
DMC: Direct material consumption	1.77	50.47	5.28	6.26	5.98	0.70	**87.8**	(Mt)
TMC: Total material consumption	11.6	100.1	21.82	6.87	6.05	4.07	**211.1**	(Mt)
Total CO_2	5.68	36.60	15.05	23.9	18.9	2.11	**157.9**	(Mt)
Total EF	2.97	9.47	8.44	6.41	4.98	1.17	**55.3**	(Mgha)
INTERNALISATION								
Ratio of DMC / TMC	15%	50%	24%	91%	100%	18%	**42%**	%
MFA-EF PER PERSON								
DMC per capita	0.22	6.22	0.65	0.77	0.74	0.09	**10.8**	(t/cap)
TMC per capita	1.43	12.33	2.69	0.85	0.74	0.50	**26.0**	(t/cap)
Total CO_2 per capita	0.70	4.51	1.85	2.95	2.33	0.26	**19.5**	(t/cap)
Total EF per capita	0.37	1.17	1.04	0.79	0.61	0.14	**6.82**[a)]	(gha/cap)
PROPORTIONS OF TOTAL								
DMC %	2%	57%	6%	7%	7%	1%	**100%**	%
TMC %	5%	47%	10%	3%	3%	2%	**100%**	%
CO_2	4%	23%	10%	15%	12%	1%	**100%**	%
EF%	5%	17%	15%	12%	9%	2%	**100%**	%

a) This number for the Ecological Footprint does not include (non-transport related) built land area in the South East which accounts for another 0.10 gha/cap.

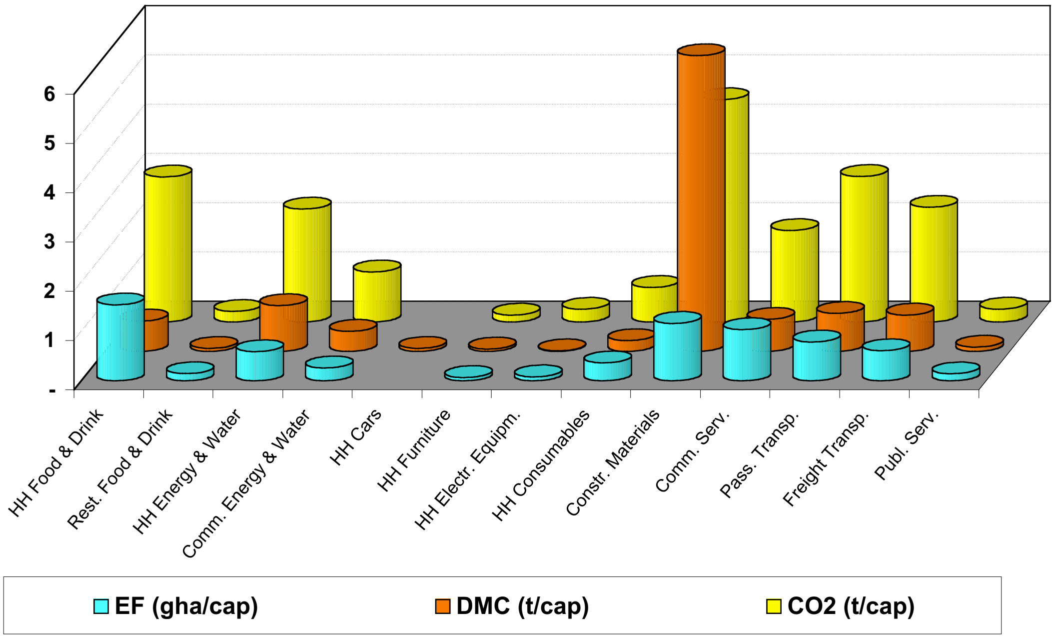

Figure 8.5 Direct Material Consumption (DMC), Ecological Footprint (EF) and CO_2 emissions of household and service sector consumption in the South East in 2000

Ecological footprint

- The calculation for ecological footprint (EF) shows a total for the South East region of **55 million** global hectares (Mgha). This equates to **6.8 global hectares per person.**
- The total EF from all activities is 29 times the physical land area of the region (1.9 million hectares). The total construction footprint area ('real land' + 'energy land') is 5 times larger than the actual area of the region. (As the name suggests, 'global hectares per year' are a notional accounting quantity distributed around the world).
- The largest single component of the total EF is the food/agriculture sector, with 25%of the total.

'Energy land' and 'real land' EF

- Table 8.2.2 provides a further analysis of the Ecological Footprint, i.e. a breakdown in '***real land'*** and notional '***energy land'*** requirements of economic activities/sectors. Most of the real land is needed for agriculture (0.78 gha/cap): but also commercial services have a high demand of real land (0.56 gha/cap) due to a high level of paper consumption (for which forests are needed). All together the highest contributions to the footprint come from the categories *0: Food and Agriculture* (1.69 gha/cap), *5: Construction* (1.17 gha/cap) and *7: Transport Services* (1.40 gha/cap), see also Figure 8.6.

Table 8.2.2 Energy and Real Land Ecological Footprints of the South East in 2000 per activity category

Activity category	Subcategory	Energy Land EF (gha/cap)	Real Land EF (gha/cap)	Total EF (gha/cap)	Energy Land % (% of item)	Real Land % (% of item)	EF % of total
0: Food & Agriculture	Households	0.763	0.779	1.54	49%	51%	22%
	Restaurants	0.055	0.091	0.146	38%	62%	2%
1: Energy & Water	Households	0.594	-	0.594	100%	0%	9%
	Commercial services	0.262	-	0.262	100%	0%	4%
3: Man. Durables	HH furniture	0.036	0.032	0.069	52%	46%	1%
	HH appliances	0.083	0.001	0.084	99%	1%	1%
4: Man. consumables		0.181	0.185	0.366	49%	51%	5%
5: Construction		1.17	-	1.17	100%	0%	17%
6: Consumer Services		0.480	0.560	1.04	46%	54%	15%
7: Transport Services	Passenger transport	0.784	0.006	0.790	99%	1%	11%
	Freight transport	0.613	-	0.613	100%	0%	9%
9: Public Services		0.067	0.077	0.145	46%	53%	2%
Built land area[a)]		-	0.104	0.104	0%	100%	2%
Total EF		5.09	1.84	6.92	74%	27%	100%

a) Built up areas, gardens and other urban areas. This land area does not include transport infrastructure as this is included in the transport section.

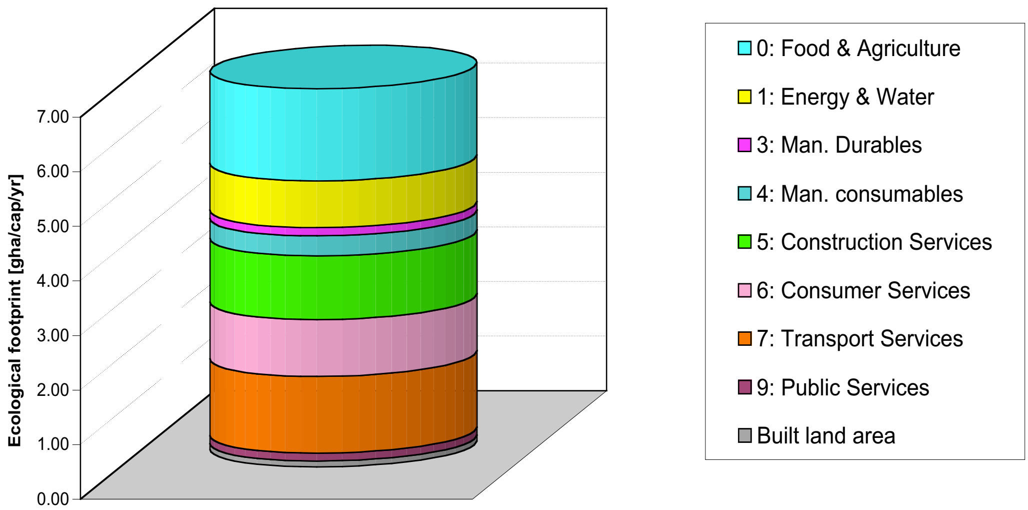

Figure 8.6 Ecological Footprint components of the South East in 2000 per activity category

Analysis by CN material types

A vertical analysis (along the CN sections) shows that the highest material consumption is in Section V (mineral products). As Table 8.2.3 shows, aggregates (CN 25) and mineral fuels, oils and products (CN 27) together account for 77.5 Mt DMC and 109 Mt TMC respectively. Mineral fuels and products alone represent 26% of all Direct Material Consumption. Accordingly, CO_2 emissions of this sector is the highest with 69.3 Mt or 44% of all CO_2 emissions in the South East in 2000. The same can be said for the Ecological Footprint: one third of the total EF (2.25 of 6.82 gha/cap) is due to the consumption of mineral (fossil) fuels.

Other sections with high Ecological Footprints are *Section X* (paper and products; 0.99 gha/cap, *Section I* (live animals and products; 0.96 gha/cap) and *Section IV* (food products; 0.83 gha/cap).

Table 8.2.3 MFA and EF results for consumption in the South East in 2000, broken down by CN 2-digit groups[5] (largest 5 categories are shown in bold: detailed breakdown in Chapter 9)

CN code (2-digit level)		Direct Material Consumption (DMC) ('000 t)	Total Material Consumption (TMC) ('000 t)	CO_2 Emissions ('000 t)	Ecological Footprint (EF) ('000 gha)	EF per capita (gha/ cap)	% of total EF %	% of total TMC %
Section I	Live animals; animal prodts	1,385	8,389	10,350	7,787	0.960	14%	3%
Section II	Vegetable products	1,160	3,723	3,115	1,172	0.144	2%	2%
Section III	Animal / vegetable fats / oils	34	152	117	232	0.029	0%	0%
Section IV	Food products	3,801	14,941	14,459	6,767	0.834	12%	6%
Section V	Mineral products	77,514	109,380	76,662	19,358	2.385	35%	45%
Section VI	Chemical products	15,737	32,152	25,427	6,589	0.812	12%	13%
Section VII	Plastics, rubber etc	1,198	5,884	4,437	1,177	0.145	2%	2%
Section VIII	Hides & skin products	30	233	100	26	0.003	0%	0%
Section IX	Wood products	2,692	6,693	2,322	670	0.083	1%	3%
Section X	Paper & board products	3,666	17,600	11,247	8,017	0.988	14%	7%
Section XI	Textile products	255	2,941	1,796	574	0.071	1%	1%
Section XII	Footwear, headware etc	29	-	-	-	-	0%	0%
Section XIII	Stone, cement, ceramics etc	8,032	10,442	2,276	589	0.073	1%	4%
Section XIV	Semi/precious stones & metals	3.11	3.11	-	-	-	0%	0%
Section XV	Base metal products	1,884	22,028	3,952	1,022	0.126	2%	9%
Section XVI	Machinery, appliances	329	7,390	4,919	1,568	0.193	3%	3%
Section XVII	Vehicle products						0%	0%
Section XVIII	Optical, medical etc	1.87	6.60	2.61	0.68	0.000	0%	0%
Section XIX	Arms products					-	0%	0%
Section XX	Misc manufacture	96	593	428	111	0.014	0%	0%
Water		1697919	763,657	368	96	0.012		0%
Other (not specified)		1,149	1,791	378	98	0.012	0%	1%
OVERALL TOTAL	(double counting corrected)	87.8 Mt	211 Mt	158 Mt	55.3 million gha	6.82 gha/ cap[a)]	100%	100%
TOTAL PER CAPITA		10.8 t/cap	26.0 t/cap	19.5 t/cap	6.82 gha/cap[a)]			

a) This number for the Ecological Footprint does not include (non-transport related) built land area in the South East which accounts for another 0.10 gha/cap.

Figure 8.7 shows a comparison between material inputs and outputs of the economic system of the South East. A total of 87.8 Mt of materials is directly consumed (DMC); on the output side there are CO_2 emissions (43.1 Mt of carbon) and waste (35.4 Mt). With respect to materials, the construction sector has

[5] Section subtotals do not necessarily add up to the overall total as they are not double counting corrected.

the highest input and the highest output in the form of waste[6]. With respect to CO_2 (or carbon) emissions however, the domestic as well as the commercial sector is much more significant.

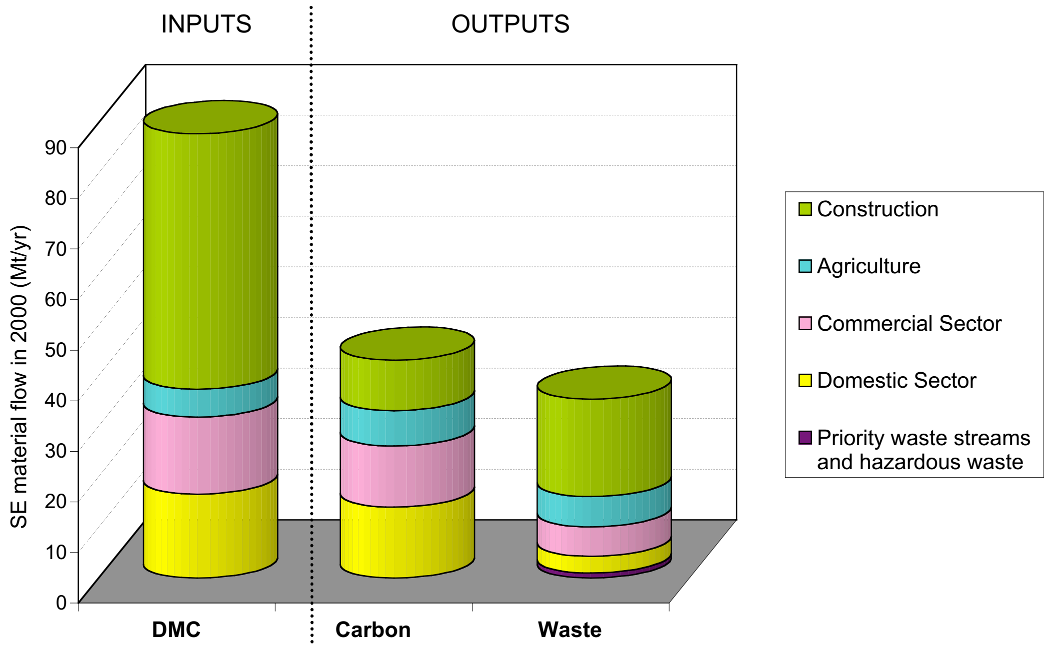

Figure 8.7 Mass balance data for consumption in the South East in 2000 (NB: CO_2 emissions have been converted in carbon figures)

8.2.3 Ecological footprint analysis

Internalisation and expenditure ratios

'Internalisation: this is an experimental measure, based on the ratio between direct and total material consumption (DMC/TMC). The lower part of the main summary tables 8.2.4 shows this measure calculated for each of the consumption sectors. A low internalisation ratio shows a large difference between DMC and TMC, and hence a situation where the indirect flows are much larger than the direct flows.

- The least internalised sectors (i.e. the most intensively manufactured) are the cars and electronic products:
- The most internalised sectors (i.e. where production and consumption have the largest overlap in accounting frame) are the construction and transport sectors.

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[6] For more details on waste please refer to Chapter 4.

Consumer expenditure

The same summary tables 8.2.4 show a comparison of the EF of different consumption sectors, with the average financial spend per household (ONS 2002). This should be viewed with caution as the allocation and definition of expenditure headings is not necessarily the same as the equivalent of the EF consumption sectors.

If the overall result is taken at face value, this shows that each pound of the average spend per person per week, of £183, produces an average EF of 373 global m^2 (0.04 gha).

The sectors with the largest EF per pound are the food and the energy sectors, at 550 and 1200 global m^2 /£/week/person. This is a topical way to communicate results – i.e. "the average person's energy bill of £20 per month causes causes 2_ hectares of damage somewhere in the world".

Production/consumption ratios

One angle on the above question of production vs consumption is shown by a direct comparison. Table 8.2.4 below shows a very approximate mapping of regional ***production*** (taken as physical activity within the boundary which results in the direct emissions of CO_2): against regional ***consumption*** (assumed as direct/indirect physical activity and CO_2 emissions associated with final consumption of goods and services). The factor of CO_2 emissions here is more useful, as the data exists for both production and consumption, unlike the EF factors which have not been calculated in detail for production.

This exercise shows firstly that the allocation question is far from being solved in EF methodology. On the production side, the apparently watertight framework shown in economic input-output tables, (here shown in the summary version of the REWARD project database), is on close inspection dependent on data definition, boundary definition, final demand definition and so on. On the consumption side of EF calculation, the appropriate definitions for boundaries, activities etc are still being debated at international level. Therefore the table shows mainly some interesting work in progress, rather than a final product: however on the way there are some topical results as follows.

Table 8.2.4 Comparison of CO_2 emissions allocated to regional production sectors and consumption sectors
Source: AEA Technology: the REWARD database, available on www.reward-uk.net

		Summary of consumption sectors							
Summary of production sectors	Totals ['000 t]	Food	Utilities	HH Durables	HH Consumables	Construction	Transport	Comm services	Public services
Agriculture, forestry and fishing	699	699							
Basic Metals	230			230					
Chemicals	1032				1032				
Clothing and Leather	7				7				
Construction	483					483			
Domestic: (allocated 40/60 energy / transport)	22355		8942				13413		
Education	1458								1458
Electrical Machinery	46			46					
Electricity	11265		11265						
Electronics	45			45					
Fabricated Metal Products	105			105					
Food, Drink and Tobacco	419	419							
Gas distribution	188		188						
Health and Social Work	684								684
Hotels and catering	270							270	
Manufactured Fuels	3095						3095		
Manufacturing and Recycling	616			616					
Mining / Oil and Gas	379		379						
Miscellaneous Services	322							322	
Non-metallic mineral products	1921			1921					
Paper, printing and publishing	1696				1696				
Public Administration	1329								1329
Retail	1614				1614				
Rubber and Plastic	175			175					
Services	2498							2498	
Textiles	39				39				
Transport	4818						4818		
Waste Treatment	156							156	
Water Supply	58		58						
Wood / Wood products	95			95					
Total CO_2 in 'regional production'	58096	1118	20833	3231	4387	483	21325	3246	3471
Total CO_2 in 'regional consumption'	162910	23900	42480	3230	5680	36600	23900	25010	2110
Ratio of consumption / production	36%	5%	49%	100%	77%	1%	89%	13%	165%

- The first feature is that the reported CO_2 emissions in production are 36% of the total CO_2 emissions in consumption. This is some reflection of the ecological footprint effect. More specifically it is a reflection that two thirds of the physical activity which keeps the South East region in the material style to which it is accustomed, takes place elsewhere in the world.

- The food and construction sectors each show production as a very small proportion of consumption. This is an indication that the great majority of actual production takes place elsewhere (or under other headings).
- Utilities (mainly direct energy supply) shows a 2:1 difference: this is due to the external effects of power generation, and the fossil fuel cycle.
- Transport shows almost exact correspondence between production and consumption: this is some kind of validation of the methodology, in that CO_2 emissions are based on direct measurement of physical activity within the region.
- The higher figure in 'public services' reflects the fact that in these preliminary versions of the regional MFA-EF accounts, 'public administration' does not yet include health, education, defence or other major parts of the public sector.

8.3 Food and Agriculture

8.3.1 Summary of results

The ***consumption by weight*** per year of all food and drink in the South East region shows the following totals (defined as ***Direct Material Consumption***):

- Total food consumed by households in the South East region: ***5.0 million tonnes*** (620 kg per person per year = 1.7 kg per person per day).
- Total food consumed by commercial/public catering in the South East: ***0.9 million tonnes*** (111 kg per person).
- Total direct weight of packaging supplied with household food in the region: ***0.66 million tonnes*** (81 kg per person = 0.2kg per day).

Over 1 million tonnes per year of ***food and drink goes to waste*** directly, of which 88% goes to landfill disposal:

- 700,000 tonnes of household food is wasted, at an estimated rate of 14% of the total.
- 386,000 tonnes of catering food is wasted, at an estimated rate of 43% of the total.

The Total Material Consumption Requirement of food and drink (TMC) is much larger (this is defined as the total life-cycle-wide material use associated with domestic consumption activities, including indirect flows imported but minus exports and associated indirect flows):

- Total materials involved in food consumption in households in the South East region: ***25 million tonnes per year*** (3 tonnes per person per year = 8 kg per person per day).
- Total materials involved in final food consumption in commercial/public catering in the South East: ***2 million tonnes per year*** (250 kg per person per year).
- Total materials involved in packaging of all food in the region: ***4.14 million tonnes*** (500 kg per person per year = 1.4 kg per day).

The ***ecological footprint (EF)*** of food/drink consumption in the South East is the consumption sector with the largest single EF: equivalent to over a quarter (25%) of the total EF from all activities:

- Food/drink in households: 1.48 gha (global hectares) per person per year
- Food/drink in catering: 0.15 gha per person per year
- Food/drink packaging: 0.07 gha per person per year

In contrast to other sectors, the ***'energy land'*** (notional land to take up energy and emissions) is of a very similar size to the ***'real land'*** (actual land used in food production). Each is approximately 0.8 gha/cap.

In terms of the breakdown of ***food types,*** including both household and catering:

- Meat and meat/dairy product consumption accounted for two thirds (66%) of the total EF from food and drink.

- Cereals and other plant based food accounted for ***23%*** of the total EF.
- Drinks of all varieties accounted for ***6%*** of the total EF.
- Packaging of all kinds accounted for ***4.5%*** of the total EF.

8.3.2 MFA–EF results for the region

Definition of food/agriculture

As a ***'production'*** sector this represents the primary industries of agriculture, forestry, fisheries, together with the manufacturing sectors of food and drink processing, and the service sector of distribution, retail, hotels and catering.

As a ***'consumption'*** sector this category includes all food consumed by individual households and restaurants as well as packaging of household food. Packaging of restaurant food is included in the commercial sector analysis; food waste is included in the waste section (see Chapter 4). A detailed description of MFA and EF calculations and results for food have been presented in Chapter 3.4.

Food and drink consumption tables

Table 8.3.1 Direct Material Consumption (DMC) and Total Material Consumption (TMC) of food and drink in households and restaurants in the South East in 2000

CN code	CN description	Direct Material Consumption (DMC)		Total Material Consumption (TMC)	
2 digits		Household food & drink	Catering food & drink	Household food & drink	Catering food & drink
		('000 t)	('000 t)	('000 t)	('000 t)
	Total (double counting corrected)	5,007	502	24,638	2,022
		-	-	-	-
	Food products:				
02	Meat and edible meat offal	239	44.7	1,864	348
				1,705	261
03	Fish and crustaceans, molluscs etc	63.3	9.7		
				4,192	17.9
04	Dairy produce; birds' eggs; natural honey etc	1,025	2.5		
07	Edible vegetables and certain roots and tubers	623	88.2	2,013	293
				1,095	27.9
08	Edible fruit and nuts; peel of citrus fruits/ melons	381	9.7		
09	Coffee, tea, mate and spices	20.7	-	227	-
				40.0	-
11	Products of milling industry; malt/starchesetc	18.1	-		
				152	-
15	Animal or vegetable fats oils, waxes etc	33.8	-		
				1,936	-
16	Preparations of meat, fish, shellfish etc	154	-		
17	Sugars and sugar confectionery	54.9	-	172	-
18	Cocoa and cocoa preparations	21.5	5.9	124	32.3

CN code	CN description	Direct Material Consumption (DMC)		Total Material Consumption (TMC)	
2 digits		Household food & drink	Catering food & drink	Household food & drink	Catering food & drink
		('000 t)	('000 t)	('000 t)	('000 t)
19	Preparations of cereals, flour, starch or milk;	608	42.2	2,173	123
20	Preparations of vegetables, fruit, nuts etc	384	-	1,472	-
21	Miscellaneous edible preparations	81.0	26.2	595	169
22	Beverages, spirits and vinegar	638	273	2,731	750
	Packaging of household food				
39	Plastics and articles thereof	169	a)	974	a)
48	Paper and paperboard; paper pulp articles etc	71.6	a)	452	a)
70	Glass and glassware	273	a)	745	a)
72	Iron and steel	117	a)	865	a)
76	Aluminium and articles thereof	28.2	a)	1,108	a)

a) Packaging materials from restaurants is included in the commercial sector analysis.

Table 8.3.2 CO_2 emissions and Ecological Footprint of food and drink consumption in households and restaurants in the South East in 2000.

CN code 2 digits	CN description	CO_2 Emissions of Food & Drink in Households ('000 t)	of Food & Drink in Households ('000 gha)	**Ecological Footprint** of Food & Drink in Restaurants ('000 gha)	of Food & Drink in Restaurants ('000 t)
	Total (double counting corrected)	23,865	1,731	**12,516**	**1,188**
		-	-		
	Food products:				
02	Meat and edible meat offal	3,238	587	**2,071**	**557**
03	Fish and crustaceans, molluscs etc	1,096	168	**1,047**	**161**
04	Dairy produce; birds' eggs; natural honey etc;	5,243	18.4	**3,943**	**8.3**
07	Edible vegetables and certain roots and tubers	1,311	187	**448**	**63.6**
08	Edible fruit and nuts; peel of citrus fruits/melons	1,365	34.8	**423**	**10.8**
09	Coffee, tea, mate and spices	182	-	**112**	**-**
11	Products of milling industry; malt/starches etc	22.3	-	**20.8**	**-**
15	Animal or vegetable fats, oils, waxes etc	117	-	**232**	**-**
16	Preparations of meat, fish, shellfish etc	2,783	-	**822**	**-**
17	Sugars and sugar confectionery	120	-	**68.3**	**-**
18	Cocoa and cocoa preparations	144	39.2	**159**	**43.6**
19	Preparations of cereals, flour, starch or milk;	1,774	71.6	**924**	**41.8**
20	Preparations of vegetables, fruit, nuts etc	1,280	-	**512**	**-**
21	Miscellaneous edible preparations	709	208	**425**	**162**
22	Beverages, spirits and vinegar	2,455	417	**705**	**140**
	Packaging of household food:				
39	Plastics and articles thereof	856	a)	**222**	**a)**
48	Paper and paperboard; paper pulp articles etc	193	a)	**130**	**a)**
70	Glass and glassware	331	a)	**86**	**a)**
72	Iron and steel	265	a)	**69**	**a)**
76	Aluminium and articles thereof	380	a)	**98**	**a)**
	Total EF of food consumption per capita (gha/cap)			1.47	0.15
	Total EF of food packaging per capita (gha/cap)			0.07	a)

a) Packaging materials from restaurants is included in the commercial sector analysis.

Five million tonnes of food were consumed in South East households in 2000. This equates to a total material consumption of about 25 million tonnes, CO_2 emissions of nearly 24 million tonnes and an Ecological Footprint of 12.5 million hectares. Tables 8.3.1 and 8.3.2 show that dairy products in household food have the highest impact in all categories, followed by the consumption of meat and fish. In restaurants meat consumption has the highest environmental impact.

Energy land/real land in food EF

Table 8.3.3 Energy and real land EF analysis of household/catering food consumption in the South East in 2000

('000 gha) Material/Product	Energy Land EF Household	Real Land EF household	Energy Land EF catering	Real Land EF catering	Subtotal household	Subtotal catering	TOTAL	% of TOTAL
Animal based food	3,285	4,915	241	633	8,200	874	9,074	66.21%
Plant based food	1,753	1,261	100	73.7	3,014	174	3,188	23.26%
Drinks	632	66	108	31.9	698	140	838	6.11%
Food packaging	524.2	80.2			604	0	604	4.41%
Subtotal EF	6,194	6,322	449	739	12,516	1,188	13,704	100.00%
Subtotal EF capita (gha/cap)	0.76	0.78	0.06	0.09	1.54	0.15	1.69	
Total energy land	6,643							
Total 'real' land	7,061							

Table 8.3.3 and Figure 8.8 show that about the same area of real land and notional energy land is required to provide food. Animal based food requires by far the largest area of both energy and real land. The packaging of food as well as drink production are energy intensive processes; together they account for about one fifth of the energy land EF.

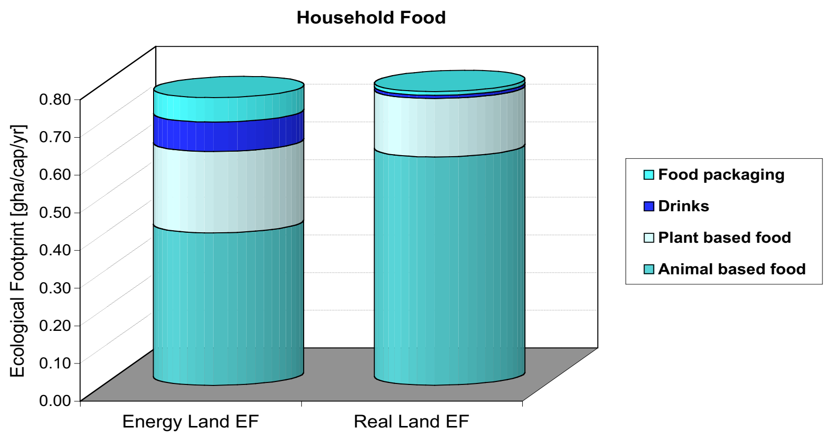

Figure 8.8 Energy and real land EF analysis of household food consumption in the South East in 2000

Imports, production and consumption

The balance of regional consumption, production, imports and exports would be the starting point for investigation of the possibilities for minimising the EF of the food system in the region. However existing regional data is not able to show in detail the balance of production and consumption for specific food items. As most food items are the product of a complex national industrial and distribution system, it is more practical to look at the South East in relation to the UK, and the UK in relation to the rest of the world.

For UK food consumption as a whole:

- Over 31% by weight is imported from overseas, of which over 99% arrives by ship.
- The UK ***agricultural imports*** chart below shows year to year fluctuations but some very clear trends: imports of 'agricultural raw materials' in particular have doubled each decade from 1970.
- The UK ***average crop yield*** for all cultivated land is 6.6 tonnes/ha, over twice the world average of 2.7 tonnes/ha.
- The UK average input of ***chemical fertilizer*** is 0.35tonnes/ha.

The South East regional farm production includes for some basic data (again there are large fluctuations so this data is taken as an average 1991–2001, from DEFRA sources as in ONS 2002):

- 13% of the English productive land area under cultivation, or 1.16 million hectares.
- Cereal production: 2.7 million tonnes of wheat, or 23% of UK production.
- On the UK average data, the input of chemical fertilizer across the South East region would be 600,000 tonnes, mainly in the form of nitrogen and phosphorus compounds.

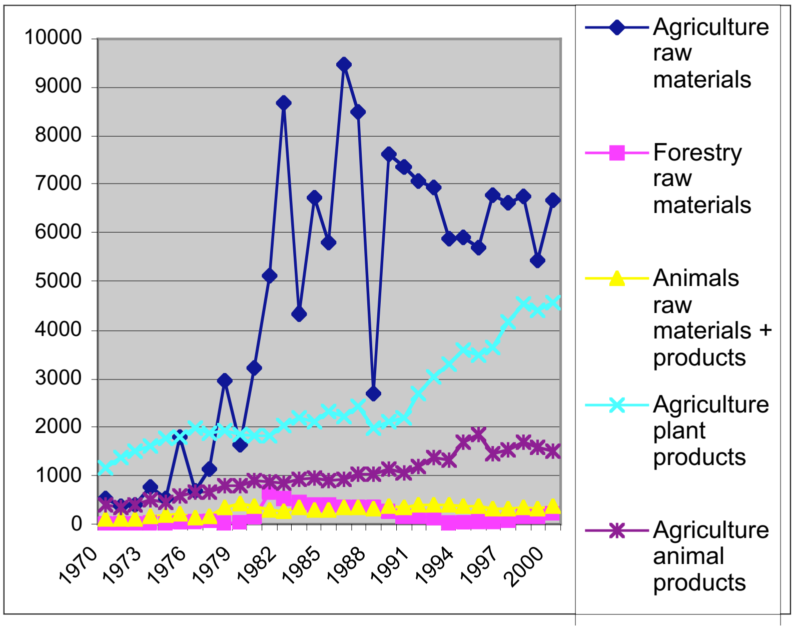

Figure 8.9 Imports of agricultural materials to the UK, 1970–2000

8.3.3 Trends, scenarios and implications

Food/agriculture policy

There are many layers to the complex and often controversional policy agenda on food production and the agricultural system. These are expected to have profound effects on the production of food, food chains and the impact of agriculture on the countryside and rural economies.

- EU CAP reforms; Environmental criteria; (Second objective)
- Set aside and production quotas
- UK sustainable food and farming strategy

The South East region has a large and productive farming sector in some areas, and also very intense competition between urban and rural landuses. Much of the South East region (19%) is subject to Green Belt policy where agricultural land values should be constrained, but in reality are pressured by quasi farm uses such as horse stabling and garden centres. The designation of the South Downs National Park adds further constraints to agricultural diversification.

Future trends and driving forces

The net effect of the above policy and market trends is expected to be quite rapid changes in the structure of production in the UK:

- Consolidation into larger units of production, where these are competitive with EU and world markets.
- New forms of agri-industrial products, including pharmaceuticals and specialist chemicals.

- New forms of niche food/drink products and markets, such as local cheeses, fruits or wines. This is of especial interest to this project, because it would tend to localise the combined production/ consumption of food and directly influence the EF of the food chain.
- For the remainder of the landscape, particularly the more diverse or less productive areas, the pattern of agriculture and forestry will shift towards ‘diversification’ and ‘extensification’, with environmental and amenity objectives to the fore.

For food consumption, it is clear that the great majority of residents of the South East region have enough in food quantity, so future trends are more concerned with food types, sources, supply chains and other qualities. For these there are few forecasting methods apart from those of projection of current trends.

Key scenario indicators

The key scenario indicators, as representative in some ways of ‘driving forces’, can be structured as follows:

- ***Imported %:*** the trend towards greater imported (from overseas) foodstuffs is set to continue, and the shakeout of UK agriculture and the CAP reform may well accelerate this process.
- ***Vegetarian %:*** this affects the balance between meat-based food (generally energy intensive) and others (less intensive). The current levels are 32% meat-based, 47% vegetable-based, and the remainder in drinks. Optimistic projection of the spread of vegetarian diets would see further diminishing of meat products.
- ***Organic production %:*** at present this covers 0.6% of food volumes by weight, but has been increasing by 15% per year over the last decade. There are different opinions on whether this trend will continue or level off.
- ***Chemical intensity***: the inputs by weight of chemical fertilizers and pesticides have increased dramatically in the last 50 years. The organic component might be taken as the converse of chemical inputs. However it is likely that chemicals inputs by weight are likely to decrease as a result of precision agriculture (use of GIS, GPS, targeted doses, fine spray techniques etc); this trend will be independent of organic production. To some extent, chemical intensity can be taken as a proxy for the overall energy intensity of production and hence the EF.
- ***Packaging %*** (by weight): food packaging by weight has increased slowly, but more rapid is the shift from low-energy (brown paper) packaging, to higher energy materials (plastic film and vacuum packing.
- ***Composting of food waste %*** (by weight): there is limited re-use of food for animal feed from institutional catering. The current levels of composting of food waste are a fraction of 1%. However the regional waste strategy contains objectives to increase this fraction.

Future scenarios for food/agriculture

For food consumption, it is clear that the great majority of residents of the South East region have enough in food quantity. The implication is that future trends will be more concerned with food types, sources, supply chains and other qualities. For these there are few forecasting methods apart from those of projection of current trends.

In terms of future trends, total consumption is relatively static, but there is a rapid growth trend towards high-energy, processed and air-freighted imports with high EF factors.

Table 8.3.4 Scenario settings for food and agriculture

FOOD & FARMING:	SCENARIO DRIVERS: EFFECT ON TOTAL FOOTPRINT IN 2020							MAIN SUB-TYPES				
	Stock factors	consumption factors	production factors	technology factors	activity / stock	waste factors	TOTAL CHANGE E.F.					
	Imported %:	vegetarian %	organic %	Chemicals as % of yield t	packaging as % of food t	Food waste composted %	To 2020	animal products	Vegetable products	Animal / veg fats/oils	Food products	drinks
Baseline 2000	31%	15%	2%	6%	6%	2%						
F-0 High growth	Rapid growth	Decline	Decline	Growth	Rapid growth	Growth	+50%					
F-1 Business as usual	Growth	Static	Static	Static	Growth	Static	0					
F-2 low growth:	Static	Growth	Growth	decline	Static	Decline	-50%					
F-4 Factor Four:	decline	Rapid growth	Rapid growth	Rapid decline	decline	Rapid decline	-75%					

- ***F-1: business as usual scenario***: this contains the default case, based on a continuation of current trends. This sees a rise in packaging, processing and imports, alongside a compensating rise in the proportion of vegetarian production, organic production and food waste composting. The effect of such trends by 2020 on the total EF for food and drink is in the region of +18%, or a growth rate of 1% per year. This same trend continued by 2050 would produce a 64% rise in EF.
- ***F-0: high growth scenario***: in a scenario of rapid economic growth, the food supply and agriculture sectors are converted to a free market model more than they are already. While CAP subsidies fall, imports and chemical production rise rapidly, and there is also a rise in the amount of pre-cooked convenience foods. The native farming sector in the South East region is shifted towards niche and leisure farming and other diversification. The effect of such trends by 2020 for food and drink is to increase the total EF roughly by 50% at an annual rate of 2.25%.
- ***F-2: low growth scenario***: in a scenario of market failure and environmental hazards, the current consumption levels of the affluent South East cannot be taken for granted. While actual food shortages are temporary, prices are expected to rise steeply due to crop failures overseas, and food hazards have a strong effect on the spending choices of many households. The result is a rapid move back towards localised production, aided by rapid warming of the climate, and much of which in the South East is carried out by householders or hobby farmers determined to achieve food purity. For the urban population this is more difficult, and there is a parallel rise in demand cheap 'industrial food', some of which is chemical industry byproducts with artificial additives. In terms of the scenario indicators, local food sources and composting of food waste increase, but so does the chemical intensity and the packaging of industrial food.

F-4: Factor Four scenario:

This scenario represents something of an 'ideal' future pathway, a gradual but constructive adjustment towards a more sustainable low impact food system. This is designed to achieve a 40% reduction in EF by 2020, and a 75% reduction in EF by 2050, in line with the F-4 objectives.

- ***Imported %:*** the trend towards increased imports is reversed; the UK and South East regional production rises, with greater quantities and diversity resulting from a different approach to production, based on bio-dynamic horticulture. This is aided by climate change and increases rapidly bio-diversity and farm employment.
- ***Vegetarian %:*** plant-based diets increase rapidly to a point where 75% of the population is primarily vegetarian. This is accelerated by various food scares along the lines of the BSE and FMD episodes.
- ***Organic production %:*** the majority of regional production is converted to organic or chemical free production within 30 years. This involves an increase in precision methods including remote sensing, integrated crop management, automatic irrigation etc.
- ***Chemical intensity***: the chemical intensity decreases rapidly; both precision farming, diversification and ICM, and the shift towards arable and organic production all help to reduce chemical fertilizer and pesticide use.
- ***Packaging %*** (by weight): food packaging by weight is maintained as is, but there is a rapid switch to re-useable and re-cyclable containers, on low impact materials. The net effect is to reduce the EF of packaging rapidly.
- ***Composting of food waste %*** (by weight): there is limited re-use of food for animal feed from institutional catering. The current levels of composting of food waste are a fraction of 1%. However the regional waste strategy contains objectives to increase this fraction.

Implications for food/agriculture policy

The simple view of the implications of the above, is based on food and agriculture as the second largest consumption sector, with over 25% of the total EF in consumption. Therefore if there is to be a conscious set of policies aiming towards a Factor Four reduction in food/agricultural systems, the implication is that this very challenging task should be able to combine a range of factors:

- ***Consumer demand and preference***: this is crucial in leading the way. It is likely to be as much 'push' from food scares, diet concerns and possibly the input of health insurance companies with customised diet programmes, as 'pull' from simple consumer preference. The turning point may be when retail chains realise there is more profit in higher-value high quality niche products, than in the conventional approach to volume sales.
- ***Food technology and supply chains***: production technology is likely to make it possible to enable greater quality and diversity, through IT-based precision methods. At the same time there is growing awareness of the value of natural growing cycles and the uses of plant genetic capital in medicinal and material sciences. Regulation of food supply chains should take account of these possibilities, together with a wider awareness of risks and potential for misuse in unhealthy diets. There may be legal developments, e.g. the current suits against producers of food which lead to obesity, which focus attention on the risks for both producers and consumers.

- ***Food markets and subsidies:*** the vital key to this structural shift towards a sustainable agriculture system is the economic management of food markets and subsidies. The current CAP reform process is considering among other things the best way to achieve food quality and safety while safeguarding environmental standards. It is suggested that a comprehensive system of taxes and subsidies to reflect global social/environmental costs/benefits, will over time lead towards a more equitable and more balanced food supply and distribution system.
- ***Global trade and international development:*** at the same time as re-thinking regional and local production, it is crucial that the benefits to the developing world of basic food production are not lost. A strategic convergence programme will help to diversify production in the developing world, to move away from the current mono-culture of cash-crops which are so vulnerable to commodity prices and extreme weather events.
- ***Agricultural land markets and management***: the economic ‘distortion’ in farm land values is likely to increase, as other criteria such as environmental objectives, leisure uses and landscape amenity also increase. Land especially in crowded regions such as the South East will also have a rarity value which can only increase. As is underway in Scotland at present, there is a strong case for the restructuring of community land access, to enable new forms of ‘sustainable rural enterprise’ and ‘low-impact farming’ to develop in a context of rising land values. There is also a case for active intervention or constraints on private land ownership, again in the South East where extreme wealth is leading towards uncontrollable acquisition of land holdings.
- ***Food waste management:*** at present the volumes of food waste are increasing, while recovery of food waste is at a minimum level. In the F-4 scenario, food waste is intensively re-used and re-cycled in terms of composting.

Role of regional policy

Regional policy has had very little engagement with food issues since World War II, when basic production was an overriding priority. This is now changing, and further rapid developments are likely, with a range of factors:

- ***Regional image and marketing*** and the role of food and drink: The Countryside Agency programme ‘Eat the view’ is a forerunner of more regional based food activity, already well established in many EU countries.
- ***Food and drink production*** as a priority sector for economic development: the industry is often low skill with high environmental impact, and is seen as an essential part of many regional strategies.
- ***Regional countryside policy:*** this may prioritise farm or land-related employment and intermediate labour market activity.
- ***Regional housing policy***: this may seek to encourage new forms of low impact rural housing, in order to maintain populations and landscape quality, while avoiding the spread of commuter settlements.
- ***Regional landscape policy***: in most areas the social or visual amenity is closely linked to maintenance (in both image and reality) of a populated agricultural landscape; therefore there is a strong case for encouraging the diversification and continuing production from the regional landscape.

- ***Regional climate change policy***: the extra pressures put on the landscape and habitats by climate change and extreme events (storms, floods, droughts, soil erosion, stress on species) may be ameliorated and adapted by a diversified and productive countryside.

8.4 Energy and Water

Energy is fundamental to the life of every region – but the current energy system is disrupting the global climate. This is possibly the greatest single threat to the global environment, a problem for which every nation and every region has to accept some responsibility and work together in a new kind of global order.

The footprint approach has much to offer this agenda. It provides a common platform for comparing energy and infrastructure to other sectors. It provides a direct assessment of the impact of different energy futures and energy strategies on the global environment.

The wider scope of a regional energy-climate strategy can only be sketched here. It includes 'supply-side' actions on energy fuels and markets, 'demand-side' actions for the consumption by housing, transport, industry and others, and adaptation actions for climate change itself. Renewable energy sources and combined heat-and-power (CHP) are then the long term energy sources of choice, in the transformation of the regional energy metabolism. Success in all this depends on linking a 'joined up' energy-climate strategy into housing, transport, regeneration and economic development.

8.4.1 Summary of results

Energy consumption in households in the South East region:

- Total energy consumed in households per year; 75,000 million units or kWh (kilo-Watt hours), or 9,000 units per person. Three quarters of this is supplied by gas.
- This energy supply produces over 2 tonnes of CO_2 per year per person.
- Total EF of this energy is 4.7 million hectares, or 0.6 hectares per person. This equates to about 9% of the total per person.
- Over half of the energy consumed in homes is for space heating, 18% is for cooking, lighting and appliances, and most of the remaining 24% is for heating water.
- The current price of electricity per unit is 4.5 times as much as the price of gas: (7.3p/ kWh, compared to 1.6p/kWh)

Energy consumption in services:

- Total energy consumed in services: 28,000 million units. Half of this is in gas, a third in electricity, and the rest mainly in oil.
- Total EF of this energy: over 2 million hectares, or over 4% of the total.

(industrial energy and its footprint is counted indirectly, via the products which are consumed in the region)

Energy supply and demand balance in the South East region

- Nearly all the energy produced directly within the region is in the form of electricity: 30% from coal, 25% from gas, and 40% from nuclear. The region imported about one third of its power via the national grid.

- Electricity supplied only 13% of the total energy demand in the region: but because of the relative inefficiency of power generation and transmission, the primary fuels for power were nearly 30% of the total.

New forms of energy supply

- Renewable energy supply in the South East region was under the national average, at less than 1% of the total, nearly all of this coming from waste incineration.
- The South East renewable energy strategy anticipates half of the potential coming from offshore and onshore wind farms, and most of the rest from biomass fuels.
- Woking Borough Council is possibly the most energy efficient in the UK. It has established the UK's first Energy Services Companies, demonstrated new technologies in combined heat and power distribution, and achieved a 40% reduction in its own CO_2 emissions.

Trends and targets

- The current 'best practicable' target is for renewable energy to supply 6% of the South East production of electricity. This is lower than the national target to supply 10% by the year 2010.
- At present, demand is rising slightly, while CO_2 emission are reducing slowly due to the shift to gas power.
- A recent report on energy futures foresaw the end of cheap North Sea gas, at a time when most of the world's diminishing fossil fuels reserves will be in the most politically unstable regions.
- The long term target is for the UK and the South East region to move towards the scientific target of 60% reduction in CO_2 emissions by the year 2050.
- The key question in achieving a Factor 4 reduction, is whether this can be achieved by greatly expanded renewable energy, greatly improved efficiency, or a new set of nuclear power plants.

Energy futures and scenarios

- ***F-0: high growth scenario***: this sees continuing growth at 1% per year in the EF of the regional energy supply, resulting in a 60% increase by 2050.
- ***F-1: (business as usual scenario):*** this combines the government's aspirations in the Energy White Paper, with the realities of globalised industry; the result is an EF which changes little between now, 2020 and 2050.
- ***F-2: (low growth scenario):*** this sees energy use, carbon emissions and the total EF reducing by about 1.5% per year, a result of economic stagnation and the increasing disruption of climate change, with impacts on the distribution between wealthy and poorer communities.
- ***F-4: (Factor 4 scenario):*** this combines demand reduction through pro-active efficiency programmes, and a rethinking of energy supply systems. All new development is effectively zero-energy net requirement: energy services companies mediate between suppliers,

distributors and users: regional renewable energy is a major growth industry. The result is a reduction in carbon emissions and EF of 35–40% by 2020, and 75% by 2050.

Summary of water supply and demand

- Nationally, about half of all water use is for cooling power stations. Public water supply for households and for services accounts for 30 per cent of consumption.
- Household water consumption in the South East amounts to 165 litres per person per day, or about 60,000 litres per person each year. One third of this goes in flushing of WCs.
- The energy use in the South East water supply system is 860 million units or kWh (kilo-Watt hours). Supply to households, and the drainage/sewage system, are each about 40% of the total. Most of the rest goes in leakages.
- The ecological footprint of the South East water supply system is about a sixth of 1% of the total EF per person.

8.4.2 MFA–EF results for the region

Scope of energy and water: supply and demand

The energy required to produce, distribute and supply the products and services to residents of the South East region 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.[7]

Direct energy is consumed at the household level in the form of electricity, gas, coal, wood and fuel oil[8]. A further category of 'direct heat' applies in the few cases of district heating and passive solar energy.

In this category the direct energy and water requirements of the domestic and the commercial sector are presented. The breakdown by energy carriers includes electricity, gas, fuel oil and coal (all CN code 27). The service sector is broken down in Commercial Offices, Communication and Transport, Education, Government, Health, Catering, Retail, Sport and Leisure and Other. For calculation details see Chapters 3.8 and 3.9.

Material flow analysis

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[7] 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.

[8] 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.

The physical throughput and the CO_2 emissions of energy consumption are high as it mainly relies on the combustion of fossil fuels. For the 7.5 million tonnes of fossil fuels consumed by households in the South East region, 18.6 million tonnes of CO_2 were released (3.3 Mt and 8.2 Mt for the commercial sector, respectively).

Table 8.4.1 MFA and EF of direct energy and water consumption of households and the commercial sector in the South East in 2000

MFA / EF	CN description	Households	Commercial Sector	Unit
Direct Material Consumption (DMC)	27: Mineral fuels, …	7.54	3.31	Mt
Direct Material Consumption (DMC)	Water	685.2	78.48	Mt
Total Material Consumption (TMC)	27: Mineral fuels, …	13.83	7.59	Mt
Total Material Consumption (TMC)	Water	685.2	78.48	Mt
CO_2 Emissions	27: Mineral fuels, …	18.25	8.19	Mt
CO_2 Emissions	Water	0.330	0.038	Mt
Ecological Footprint (EF)	27: Mineral fuels, …	4,737	2,120	000 gha
Ecological Footprint (EF)	Water	86	10	000 gha
EF per capita	27: Mineral fuels, …	0.58	0.26	gha cap
EF per capita	Water	0.011	0.001	gha/ cap

Footprint analysis

While the 'energy land' is large, by contrast the 'real land' area (actual physical land area) is small, for both energy and water consumption. Thus, the Ecological Footprint is mainly made of notional energy land (i.e. the forest area required to sequester the CO_2 emissions), as given in Table 8.4.2.

Table 8.4.2 Direct energy and water consumption in the South East in 2000: Breakdown of the energy land EF for different types of energy

1: Energy & Water Material/Product	Energy Land EF Households	Energy Land EF Commercial Services	Unit
Domestic energy (gas)	2,744	-	'000 gha
Domestic energy (electricity)	1,522	-	'000 gha
Domestic energy (oil)	323	-	'000 gha
Domestic energy (coal)	149	-	'000 gha
Commercial energy (gas)	-	660	'000 gha
Commercial energy (electricity)	-	1,105	'000 gha
Commercial energy (oil)	-	293	'000 gha

1: Energy & Water Material/Product	Energy Land EF Households	Energy Land EF Commercial Services	Unit
Commercial energy (coal)	-	60.5	'000 gha
Water	85.78	9.83	'000 gha
Subtotal EF	4,823	2,130	'000 gha
Subtotal EF per capita	0.594	0.262	gha/cap

Supply–demand analysis

The balance of regional energy consumption, production, imports and exports is the starting point for the possibilities for minimising the EF.

Industrial energy demand is smaller in comparison to other regions. The largest energy users reflect the modern industrial mix of the region, in chemicals, manufactured fuels, and paper/printing.

Nearly all the energy produced directly within the region is in the form of electricity. There are power stations in Oxfordshire, Thames Estuary and Kent. Gas is landed directly to refineries in the Thames Estuary: coal mining in Kent has now completely shut down, but there are still coal imports to larger industries.

Electricity supplied only 13% of the total 'final' energy demand in the region: but because of the relative inefficiency of power generation and transmission, the 'primary fuels' for this power generation were nearly 30% of the total. These primary fuels were composed of 30% from coal, 25% from gas, and 40% from nuclear power plants. The region imported about one third of its total power consumption power via the national grid.

From the overall pattern of supply and demand, (Table 8.4.3) it can be seen that households accounted for nearly half of energy demand, (including private transport). The transport sector (all sources) accounted for over 25% of the total final energy.

Table 8.4.3 Balance of supply, demand and production of energy in the South East Region

Energy demand & supply in the SE region. GWH/yr (Final energy figures adjusted for transmission / utilisation losses)	domestic	services	transport	industry	total final	total primary	final %	primary %
final energy by sector	95.7	36.3	20.5	44.8	197.4	210.0	65%	53%
power consumption	13.9	8.1	0.0	16.6	38.5	110.1	13%	28%
transport energy	40.6	12.1	13.6	3.5	69.9	74.3	23%	19%
total final energy	150.2	56.6	34.1	64.9	305.8			
final %	49%	19%	11%	21%	100%	394.4		
total primary energy	184.6	74.7	36.3	98.7		394.4		
	47%	19%	9%	25%		100%		
electricity production					78.1	223.1		
power coefficient					0.35			
fossil fuel coefficient					0.94			

Data from AEA Technology & the Reward regional database (www.reward-uk.org)

8.4.3 Trends, scenarios and policy implications

Regional policy context

The South East regional policy focuses mainly on renewable energy sources, in terms of practical actions. This can be seen in comparison to other strategies, for instance the NW which centers on energy/environment technology clusters: and the East Midlands, which focuses on radical improvements in energy efficiency.

At present only a very small proportion of electricity generation in the South East is from renewable sources (0.65%). Most of this is from landfill gas. The proportion falls to 0.05% if energy from waste is excluded. The overall regional targets now include:

- 2010: the target is 450 MW installed capacity = 4% of regional power demand.
- 2016: the target is 700 MW installed capacity = 6% of regional power demand.
- 2026: the target is 1600 MW installed capacity = 14% of regional power demand.

In the shorter term, these targets are highly uncertain. Across the UK, much depends on energy prices, financial incentives for renewables, and the financial risk/reward balance. Within the region, much depends on planning permission and the logistics of developing large infrastructure in a crowded region.

- The lower end of target range for deployment (330MW) represents a moderate deployment. For some technology areas (particularly waste) it continues the current trends within the region and so could be partly classified as BAU. For most other technologies it represents a major increase from the current minimal uptake.

- Relatively few biomass schemes appear, with existing barriers persisting, however, hybrid green waste and biomass projects are tested.
- Significant growth in grid-connected onshore wind power, in line with supportive planning policies; and an offshore wind farm is constructed off the South East coast.
- Photo-voltaic deployment continues to grow but at a moderate rate.

National policy context

The DTI Energy White Paper of 2003 contains four goals for the national energy policy:

- "to put ourselves on a path to cut the UK's carbon dioxide emissions – the main contributor to global warming - by some 60% by about 2050, as recommended by the Royal Commission on Environmental Pollution (RCEP), with real progress by 2020;
- to maintain the reliability of energy supplies;
- to promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
- to ensure that every home is adequately and affordably heated."

However there is criticism that the goals of the DTI White Paper do not contain enough of substance to form a realistic strategy, in the light of the following[9]:

- falling energy prices tend to reduce the incentive to save;
- market uncertainty makes it more difficult to invest in infrastructure;
- CHP development has fallen back to its lowest levels for a decade, despite the government's aspirations.
- the current slow reduction in CO_2 emissions is a temporary result from the shift to gas, and the anticipated shut-down of nuclear facilities is likely to push the emissions upwards again within the next decade.

Future trends and driving forces

In terms of the next decade or two, there is relative stability in consumption per household, but the gradual growth of population and decline in household size, means that the underlying trend is still upwards in line with the household growth of 8–9% per decade. There will be continuing reduction in EF from energy supply due to the phasing out of coal generation, and the introduction of renewable sources. However the long term future of the UK energy system is a fairly open question: the aspiration for a low carbon future is welcome, but the means to deliver it through government action are not obvious.

The net effect of the above policy and market trends is expected to be quite rapid changes in the structure of production in the UK. The DTI Energy White Paper avoids setting targets and projections, unlike previous papers, but it sketches out a powerful scenario in the not very distant future for the energy system in 2020, which it maintains is on the path towards the recommended 60% cut in 2050:

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[9] Institute of Civil Engineering:, 2003: Royal Commission on Environmental Pollution 2002.

"We envisage the energy system in 2020 being much more diverse than today. At its heart will be a much greater mix of energy, especially electricity sources and technologies, affecting both the means of supply and the control and management of demand. For example:

- Much of our energy will be imported, either from or through a single European market embracing more than 25 countries.
- The backbone of the electricity system will still be a market-based grid, balancing the supply of large power stations. But some of those large power stations will be offshore marine plants, including wave, tidal and windfarms. Generally smaller onshore windfarms will also be generating. The market will need to be able to handle intermittent generation by using backup capacity when weather conditions reduce or cut off these sources.
- There will be much more local generation, in part from medium to small local/community power plant, fuelled by locally grown biomass, from locally generated waste, from local wind sources, or possibly from local wave and tidal generators. These will feed local distributed networks, which can sell excess capacity into the grid. Plant will also increasingly generate heat for local use.
- There will be much more micro-generation, for example from CHP plant, fuel cells in buildings, or photovoltaics. This will also generate excess capacity from time to time, which will be sold back into the local distributed network.
- Energy efficiency improvements will reduce demand overall, despite new demand for electricity, for example as homes move to digital television and as computers further penetrate the domestic market. Air conditioning may become more widespread.
- New homes will be designed to need very little energy and will perhaps even achieve zero carbon emissions. The existing building stock will increasingly adopt energy efficiency measures. Many buildings will have the capacity at least to reduce their demand on the grid, for example by using solar heating systems to provide some of their water heating needs, if not to generate electricity to sell back into the local network.
- Gas will form a large part of the energy mix as the savings from more efficient boiler technologies are offset by demand for gas for CHP (which in turn displaces electricity demand).
- Coal fired generation will either play a smaller part than today in the energy mix or be linked to CO_2 capture and storage (if that proves technically, environmentally and economically feasible).

Key scenario indicators

The national strategy above points towards a small range of key drivers and trend indicators:

- Energy demand from services building stock
- Energy demand from household building stock

Renewable supply (from the region): the South East Renewables strategy if implemented, would provide a total of 9% of the regional power supply. There would be a small contribution to space heating by various means.

- Heat direct supply: this includes estimates of localised renewables and the effects of building design on heating requirements – i.e. passive solar energy. This does not often figure in engineering assessments, as it is technically outside the system of production and distribution. Potential design improvements for passive solar energy can amount to 50% of household energy demand, if the increasing requirement for summer cooling is taken into account.[10]
- Combined heat and power %: this is generally framed in terms of co-generation with district heating (CHP-DH).
- Energy recovery: this is the counterpart to the same item on the waste account, showing the energy contribution of the WTE programme.

Table 8.4.4a Scenario indicators and settings: these form the inputs to the spreadsheet model below

1: ENERGY & WATER	SCENARIO DRIVERS							MAIN SUB-TYPES				
	Stock factors	consum p- tion factors	produc- tion factors	techno- logy factors	activity/ stock	waste factors	TOTAL CHAN G E.F.					
	Services energy	hh energy/ m^2	renew- able %	Appliance eff	CHP %	heat %		house- hold	Serv ices	Indu stry	Trans- port	Power
Baseline 2000	31%	15%	2%	= 1	6%	2%						
F-0 High growth annual	growth	growth	Reducin g	Reducing	Reduci ng	Reduci ng	+50%					
F-1 business as usual	Stable	Stable	Stable	Stable	Stable	Stable	0					
F-2 low growth: annual	stable	stable	Growth	Growth	Growth	Growth	-50%					
F-4 Factor Four: annual	reducing	reducing	Rapid growth	Rapid growth	Rapid growth	Rapid growth	-75%					

[10] Goulding, J.R., Lewis, J.O. and Steemers, T.C. (1992) Energy Conscious Design: A Primer for Architects, Batsford for the Commission of the European Communities, London.

Table 8.4.4b Spreadsheet model for energy scenarios

Energy Scenario Summary Table	UNIT	2000	BAU 2020	F-0	F-1	F-2	F-4
FINAL ENERGY DEMAND							
gas	PJ/y	414.8	513.1	343.7	294.8	220.8	345.3
oil	PJ/y	594.3	943.2	1090.5	686.7	324.6	732.3
coal	PJ/y	17.8	47.8	27.9	22.3	6.6	20.5
renewables	PJ/y	7.6	27.0	25.0	26.6	8.0	70.3
heat	PJ/y	7.6	19.4	-294.6	-65.5	-343.7	-247.7
power	PJ/y	181.5	322.4	254.4	207.3	113.4	217.2
TOTAL FINAL DEMAND	PJ/y	1223.5	1872.9	1446.9	1172.2	329.7	1137.9
change in final demand 1995/2020			53%	18%	-4%	-13%	-7%
POWER, CHP & SECONDARY FUEL							
gas (power + secondary)	PJ/y	194.1	386.9	237.5	193.5	0.0	202.8
oil	PJ/y	8.6	130.8	86.0	70.1	0.0	73.4
coal	PJ/y	239.5	133.0	105.0	85.5	0.0	89.6
renewables	PJ/y	15.9	39.2	154.5	125.9	0.0	131.9
waste	PJ/y	10.9	48.4	127.2	103.7	0.0	108.6
nuclear	PJ/y	95.6	195.8	61.8	50.3	0.0	52.8
TOTAL POWER DELIVERED	PJ/y	564.6	934.0	771.9	629.0	0.4	659.1
CO-GEN heat output	PJ/y	7.6	19.4	-294.6	-65.5	0.0	-247.7
CO-GEN power output	PJ/y	3.0	7.8	-117.8	-26.2	-39.7	-99.1
PRIMARY ENERGY							
gas	PJ/y	511	719	469	396	0	450
oil	PJ/y	561	968	1076	688	0	733
coal	PJ/y	186	139	100	81	0	83
renewables	PJ/y	8	21	83	67	0	71
waste	PJ/y	8	35	93	75	0	79
nuclear	PJ/y	56	115	36	30	0	31
TOTAL PRIMARY ENERGY	PJ/y	1330	1997	1856	1338	0	1445
CARBON EMISSIONS							
gas		-	-	-	-	-	-
oil		-	-	-	-	-	-
coal		-	-	-	-	-	-
renewables		-	-	-	-	-	-
waste		-	-	-	-	-	-
nuclear		-	-	-	-	-	-
TOTAL CO_2 excl. power	Mt/year	74.1	105.8	113.7	78.0	45.7	83.3
		-	-	-	-	-	-
		-	-	-	-	-	-
CO_2 including power	Mt/year	102.5	140.8	144.9	103.4	28.6	109.9
other carbon sources	Mt/year	0.3	0.3	0.2	0.2	0.0	0.2
TOTAL CO_2	Mt/year	102.8	141.1	145.1	103.6	0.0	110.1
total change CO_2 1995/2020		-	37%	41%	1%	0%	7%

OTHER INDICATORS						
total CO_2 / total GDP	0.93	0.71	0.69	0.59	0.00	0.73
total CH4 emissions	220.00	55.00	22.00	22.00	0.00	22.00
total CFC / HCFC emissions	2.60	4.20	0.25	0.25	0.00	0.25

Water

Water scenario trends and drivers have been simplified to reflect the relatively small contribution of the water system in the total footprint calculation.

- Household water demand/m^2: a combination of lifestyle factors, particularly garden and car use; and technology factors on the efficiency of appliances and sanitary equipment.
- Leakage: this is basically related to the investment in new and replacement pipework.
- Regional supply balance: the proportion of the total demand met from within, or imported to the region.

Future scenarios for energy and water

Energy models and scenarios have a very long history, which this brief summary can only point to.

- ***F-0: high growth scenario***: in a scenario of rapid economic growth, the energy and water utilities are shifted more than ever to a free market, supplier dominated industry. New gas and oil sources are opened up in the Arctic and in Africa: these are globalised with a massive scale of technology, which offers reduced prices to anyone in the market. There is an increasing problem of energy withdrawal from lower income households without the correct credit rating to engage with the utilities, who now provide combined service packages of waste, energy, telecoms, security, and even health and education.
- ***F-1: business as usual scenario***: this contains the default case, based on a continuation of current trends. The UK government continues its aspirations for a carbon free future, while continuing the liberalisation and globalisation of the utilities. Offshore carbon sequestration appears to be the ultimate technical fix, enabling fossil fuel production to continue unabated while stocks last. The result is that energy, carbon and other impacts are held about stable, against continuing economic growth and regional development.
- ***F-2: low growth scenario***: in a scenario of market failure and environmental hazards, the current consumption levels of the affluent South East can fall with severe social and environmental costs. As climate change becomes ever more disruptive, harsh winters and scorching summers increase the demand for power. However the supply is from increasingly unstable countries, and hence energy prices increase rapidly, causing hardship for the less wealthy. The carbon sequestration above turns out (too late) to have drastic long term effects on deep marine bio-chemistry, with about the same irreversibility as the problem of nuclear waste . In view of this there are some attempts at homegrown renewables, and more action on basic building insulation for both summer and winter conditions.

F-4: Factor Four scenario

The Factor 4 scenario represents an aspirational mix of best practices, including those on demand, infrastructure and supply sides. It aims at a 75% reduction in CO_2 from the energy system as a whole, and hence the total EF which is closely linked. On that basis, a reduction rate of –1.8% would meet the 60% CO_2 target for 2050: a significantly higher rate of –2.5% per year would meet the Factor 4 target by 2050.

- ***Integrated energy – climate strategy***: this seeks opportunities which combine economic/ employment, with social objectives, with environmental gains. The best example here is the formation of energy services businesses in intermediate labour/training markets, to tackle energy efficiency in urban regeneration, with the strategic aim of transforming the urban environment in a rolling programme at neighbourhood level.
- ***Supply side – fossil fuels***: this scenario anticipates large price rises in gas and oil in the coming decades, which will improve the relative viability of other sources and distribution systems. At the same time the regulation of the utilities will take account of economic and social need in the market and pricing system, subsidising basic requirements by levying more extensive usage. The international carbon trading system will have a role to play in this.
- ***Supply side – renewables***: the main renewables sources in the current assessment are wind power and biomass. The scope of this may extend to photovoltaic panels, and the use of passive solar heating/cooling in building design.
- ***Supply side – combined heat and power***: the Factor 4 scenario sees CHP as the majority provider in denser urban areas, where the infrastructure is built into all regeneration and rehabilitation schemes as well as new development. This also applies to large commercial and public building complexes.
- ***Demand side – households***: the ultra-low energy house design is technically quite feasible, and there are many examples, the nearest being the BedZED development in Surrey. This and many others show that the social landlords (housing associations) are in the lead due to their life-cycle management perspective, and their ability to invest in policies and take certain levels of risk. Owner occupiers are much more difficult, and there are structural changes needed in mortgage lending, building regulations, and surveying methods.
- ***Demand side commercial***: there are also commercial and public buildings which are demonstrators of ultra-low energy. The constraints as with owner-occupier housing apply even more here; so the F-4 scenario focuses on the institutions and financial mechanisms needed to steer developers, financiers, utilities, designers, contractors and building managers into a low-energy collaboration.

Role of regional policy

Regional policy has had very little engagement with energy issues since the setting up of the CEGB and the national grid, in stages since the 1900s, and the phasing out of town gas in the 1960s. There is now a resurgence in the light of aspirations for renewable energy sources. However this is focused on regional planning, which is significant, but only part of a bigger picture which includes investment and market signals for utilities, co-generation, and energy efficiency in buildings.

To achieve anything like the Factor 4 scenario above, a much more pro-active regional energy strategy is needed than at present. This is likely to operate at urban and sub-regional level. It will achieve best practice in new development and conversions by bringing together institutions and financial mechanisms needed to steer developers, financiers, utilities, designers, contractors and building managers into a low-energy mode of practice. At the same time it will seek win-win economic and social opportunities from this agenda.

- Supply side – combined heat and power
- Supply side – renewables
- Demand side – households: aggressive energy efficiency policies for new development, also for regeneration and rehabilitation.
- Demand side– commercial: pro-active partnership arrangements on the energy services model, at an urban or sub regional scale

8.5 Household Durables

Consumption of household goods is one of the key 'life aspirations' – having got a larger house than last year, the ***average South Eastern consumer*** will then need to fit it out with the latest and best furnishings, appliances and electronic gear. This section focuses on the ecological footprint of household 'durables' – described here as cars, furniture and electrical goods, or anything of material weight in the household with an average lifetime in use of more than 1 year.

8.5.1 Summary of results

The largest single item of household consumption is of the private car/other vehicle, and the trend towards larger SUVs is accelerating the growth in material impact. However the tonnage of furniture is not far behind, although this contains a larger proportion of renewable materials:

- New cars are bought by 1 in 20 people on average every year: the result is the annual consumption of 50 kg of new car per person (415,000 tonnes per year in the South East).
- Householders consume on average 50 kg of furniture, fittings and miscellaneous fixed items (400,000 tonnes in the South East).
- Householders consume on average 13 kg per year of household electrical appliances, including washing machines, computers, television, hi-fis and so on (100,000 tonnes in the South East region).
- Almost a quarter of all appliances by weight are washing machines (22,000 tonnes per year), with fridges at 10,000 tonnes per year, large TVs (10,000 tonnes per year), and personal computers (6,000 tonnes per year).

- Overall, the household durables TMC (total material consumption) is 6% (12.5 million tonnes) of all consumption in the South East region. A third of this is from purchases of cars.

Material composition of household durables

- The main materials in a new car include, by weight, over half in steel, 11% in plastics and 11% in aluminium products. Rubber for tyres is only 5% of the total.
- In household furniture, paper/pulp based products including chipboard are a third of the total materials: wood, steel and plastics are each 8–10%.
- In household appliances, steel comprises 40% by weight, with over 20% in miscellaneous materials.

Ecological footprint of household durables

- Durable items are generally highly manufactured and hence have large indirect material and energy requirements: for every tonne of direct material consumption (DMC), there are over 12 tonnes of total material consumption (TMC). However the data available is only a sketch of a very complex set of supply chains.
- The largest single footprint item is from cars and other vehicles. Ten per cent of the ecological footprint of car use is due to manufacture and maintenance of cars.[11]
- In furniture the 'real land' footprint component is half the total, mainly due to use of wood. By contrast, in electrical goods, the 'real land' component of the footprint is only 1% of the 'energy land' component.

Trends in household durables

Future trends depend on 'saturation' and 'turnover', i.e. whether consumption slows down once all households have a particular item. This is difficult to predict as lifestyle and fashion becomes as strong an influence as functionality, and technological improvement is the main driver of new purchases.

- Past trends show growth in consumption from 1% to 3% per year in various items.
- Imports of manufactured goods have increased by 6 times in 30 years (a growth rate of 7% per year). Exports of manufactured goods have increased by 4 times (5.5% per year).
- 93% of households in the South East have a freezer, but only 31% have a dishwasher, and ownership trends are likely to reach saturation at 100%: whereas purchases of televisions is likely to grow until there is one in each room, and perhaps beyond that.
- Nearly half of households have 1 vehicle, and over a third have two: in fact only 1 in 6 have no car at all. There will be some effect in saturation of ownership, while purchases and turnover continue to grow.

Scenarios for the future

[11] This analysis is provided in Chapter 3.2.

The scenario approach is particularly important for this sector, which is less predictable and more open to a wide range of possibilities:

- ***F-0- high growth scenario***: the ‘throw-away’ economy continues to accelerate, consumers are driven by mass media to work harder and buy more; while houses continue to get larger, there is never enough room to contain all the purchases, and most products become increasingly short life before they go into the waste stream.
- ***F-1: business as usual scenario***: current trends continue with steady growth in purchases of furniture, cars and electrical goods; even when every person is the owner of all common products, and the quality of such products continues to rise, technological improvement means that new items are needed at regular intervals.
- ***F-2: low-growth scenario***: material consumption declines, but mostly for the wrong reasons – economic stagnation, social malaise and environmental disruption. The cost of energy and raw materials goes up: environmental regulations are discarded: imports decline due to international tension. Technological innovation slows down, with the result there is less reason to buy new goods.
- ***F-4: Factor Four scenario***: the win-win scenario sees the quality and efficiency of household durables continue to rise. Equally important, the fixation of consumers on acquisition of new products begins to dwindle, as more people find satisfaction in non-material experiences. Much economic growth takes place in the social economy, where sharing, networking, re-use and recycling of goods is a major economic sector.

Regional policy

The government published in 2003 its strategy for ‘Sustainable Production and Consumption’ (SCP). This is more a review of possibilities than a fixed plan of action, but the main themes include:

- “Taking a holistic approach that considers whole life-cycles of products and services, intervening to deal with problems as early as practicable in the resource/waste flow.
- Working with the grain of markets, and identifying and tackling market failures.
- Integrating SCP thinking and objectives in all policy development and implementation.
- Using a well-designed package of policy measures and following the principles of better regulation.
- Stimulating innovation in all its facets.”

The question here is how much this is a regional agenda, and something that the regional organisations can promote. It has to be said that the obvious starting point – ***consuming less ‘stuff’*** – is apparently opposite to mainstream economic policy and its goal of GDP growth. So the agenda here focuses on potential win-win opportunities:

- Promoting innovation in manufacturing technology, to increase productivity with less impact.
- Encouraging industrial clusters with integrated materials management systems.

- Innovation in materials and waste management, to create markets for re-use, recycling and other forms of recovery.
- Promoting retail clusters and networks which encourage service economies i.e. leasing and hiring for a service level, rather than one-off material purchases.
- Promoting social economy groups and networks for sharing, re-use and recycling, where this is relevant.

8.5.2 Overall MFA–EF results for the region

Definition of 'durable'

For the purpose of this study we define a 'durable' good as the purchase by householders of any material product with a useful life of more than 1 year. The example of cars: we include only new cars in this account, on the basis that second hand cars are already in the system, and do not use primary resources/energy in their production (see Chapter 3.7 for material inputs, stocks and outputs relating to cars).

It is also interesting that the word 'sustainability' in French is ***'durable'*** – i.e. stable and long lasting.

Durable items in this study comprise of cars, furniture, hard and soft floor covering and electrical equipment that are consumed by households in the South East. For extra information electrical appliances consumed by the commercial sector are listed in this section as well. It must not be double counted though, as commercial electrical equipment (e.g. photocopiers etc.) is already included in category 6: "Consumer Services". This way it was possible to present two different kinds of material analysis of the commercial sector.

Production vs consumption

There is also a need to be careful on the distinction between production and consumption. The economic category 'manufacturing' (SIC D2) was considered for the purposes of this study as intermediate production, e.g. steel for use by industry etc... However, the whole basis for MFA and EF calculations in this project was the consumption of materials and products by ***end-users***, i.e. households and the services sector. Therefore the material composition of products was taken into account only on a basic material level. For instance, it was ascertained how much steel is used to make a car and thus the steel (CN code 72: "Iron and steel") is accounted for but neither the iron ore (CN code 26: "Ores…") nor the motor, pistons, breaks etc. (CN code 73: "Articles of iron or steel") nor the complete vehicle (CN code 87: "Vehicles…").

Format of results

The numbers for electrical equipment can be presented in two ways: either as the basic materials they are made of (plastics, metals, glass, etc.) or as the final product under CN codes 84 and 85. As mentioned above the approach in this study was to allocate consumption to basic materials, i.e. the numbers under CN 84 and 85 are given as extra information only.

In this chapter we show only the totals and percentages of the total for each item: the full tables in the CN format are shown in the Appendix. These tables show for instance, that over _ million tonnes of materials were used for cars in the South East in 2000. This required a total material consumption (TMC) of 12 times that amount, over 6 million tonnes, mainly due to the consumption of steel and other metals which are highly energy and material intensive. The total material consumption (TMC) for household furniture and electrical equipment were 394,000 and 103,000 tonnes, respectively.

Table 8.5.1 Direct Material Consumption (DMC) of durable items in the South East in 2000

		House holds	House holds	House holds	Commercial Sector [a]
CN code	CN description	Cars	Furniture	Electr. Equipm.	Electr. Equipm.
		('000 t)	('000 t)	('000 t)	('000 t)
	Total Direct Material Consumption (DMC)	508	393.7	201.7	222.9
	Double Counting Correction			-98.3	-108.7
	Total DMC (double counting corrected)	508	393.7	103.4	114.3
25	earths and stone; plastering materials, lime and cement		1%		
27	Mineral fuels, mineral oils and products of their distillation	6%			
29	Organic chemicals		3%		
30	Pharmaceutical products		1%		
32	Tanning or dyeing extracts; tannins, dyes, pigments				
35	Albuminous substances; starches; glues; enzymes		1%		
39	Plastics and articles thereof	11%	8%	16%	25%
40	Rubber and articles thereof	5%	2%		
41	Hides and skins (other than furskins) and leather				
44	Wood and articles of wood; wood charcoal		16%		
45	Cork and articles of cork		0%		
48	Paper and paperboard; articles of paper pulp, paper or paperboard		32%	4%	4%
52	Cotton		6%	0%	0%
55	Man-made staple fibres		3%	0%	0%
58	Special woven fabrics; tufted textile products;		5%	0%	0%
69	Ceramic products		0%	0%	0%
70	Glass and glassware	3%	2%	8%	7%
72	Iron and steel	54%	10%	40%	42%
74	Copper and articles thereof	1%	0%	1%	0%
75	Nickel and articles thereof	0%	0%	0%	0%
76	Aluminium and articles thereof	11%	0%	3%	1%
83	Miscellaneous articles of base metal	0%	0%	0%	0%
84	Nuclear reactors, boilers, machinery and mechanical	0%	0%		
85	Electrical machinery and equipment and parts thereof;	0%	0%		
not specified	Other	9%	11%	26%	20%
	totals ('000t)	100%	100%	100%	100%
	per capita (tonnes per year)	0.063	0.049	0.013	

***a) Extra information only. MFA and EF accounts of electrical equipment in the commercial sector are included in category* 6: "Consumer Services".**

b) Extra information only. These volumes are accounted for in the basic material categories of the CN classification.

Table 8.5.2 presents the Ecological Footprint of durable items consumed by households in the South East. The EF of cars, i.e. the footprint of their manufacture and their maintenance is included in the Passenger

Transport section (*7: Transport Services*, see also Chapter 3.2 for details). All together the EF of furniture and electrical equipment in South East households adds up to 0.152 gha/cap.

Table 8.5.2 Energy and real land EF analysis of the consumption of durable items in households in the South East in 2000

3: Man. Durables	Energy Land EF	Real Land EF	Total EF	percentage of total EF in category
Material/Product	'000 gha		'000 gha	%
Furniture	201	229	430	77%
Floor covering	93	33	126	23%
Subtotal EF	294	262	556	100%
Subtotal EF per capita *(gha/cap/yr)*	0.036	0.032	0.07	
Large electrical appliances	342		342	50%
Furniture	201.30	229.00	430	77%
Floor covering	93.00	32.90	126	23%
Subtotal EF	294.00	262.00	556	100%
Subtotal EF per capita (gha/cap)	0.04	0.03	0.07	
Large electrical appliances	341.80		342	50%
Small electrical appliances	60.70		61	9%
IT equipment	39.10		39	6%
Telecommunications equipment	34.30		34	5%
Radios and TVs	108.00		108	16%
Lights	2.26		2	0%
Fire equipment	0.87		1	0%
Toys	12.24		12	2%
Electric tools	70.40		70	10%
Electr. equipm. packaging	4.11	4.61	9	1%
Subtotal EF	674	4.61	679	100%
Subtotal EF per capita (gha/cap)	0.083	0.0006	0.08	

8.5.3 Trends, scenarios and policy implications

Future trends and drivers

Consumption of durables, i.e. purchasing by consumers of new products and items at the end of the material supply chain, is driven by a combination of factors:

- Basic functional requirements: the need for washing machines and fridges is self-evident in industrialised society, particularly where households are no longer arranged around domestic labour.

- Induced/indirect functional requirements: where for instance people trade up for larger houses, then an induced demand for replacement appliances and more furnishings will be generated.
- Technological improvements and transitions: for most electrical goods there is a momentum of innovation which generates a clear need for new purchases; this is very fast in the realm of computing and mobile phones, slower in the case of hi fi systems. There are also technological regime changes, e.g. transition from tape, to cassette, CD and DVD media.
- Design and aesthetic demand: increasing numbers of kitchen appliances and furnishings are discarded and replaced as a matter of fashion and style. This is notoriously difficult to predict, except that the designers, retailers, advertisers and general media are all geared up to promote continuous or growing levels of material consumption.
- Latent demand: each of the above demands may be constrained by lack of disposable income, savings or credit: therefore macro-economic changes will have a large influence on the ability of consumers to purchase.
- The above drivers of growth are also conditioned by life-cycles and residence times, i.e. how long a product will last in functional terms, or how long it is acceptable in other terms to remain in the stock.
- Saturation effects may slow down the growth of the total market and put greater emphasis on the turnover and replacement trends for the acquisition of new goods.

These various factors can be seen in the recent trends in appliance ownership (only UK figures are available). These appear to point towards a moment at about 2020 when 100% of households will possess all that they need.

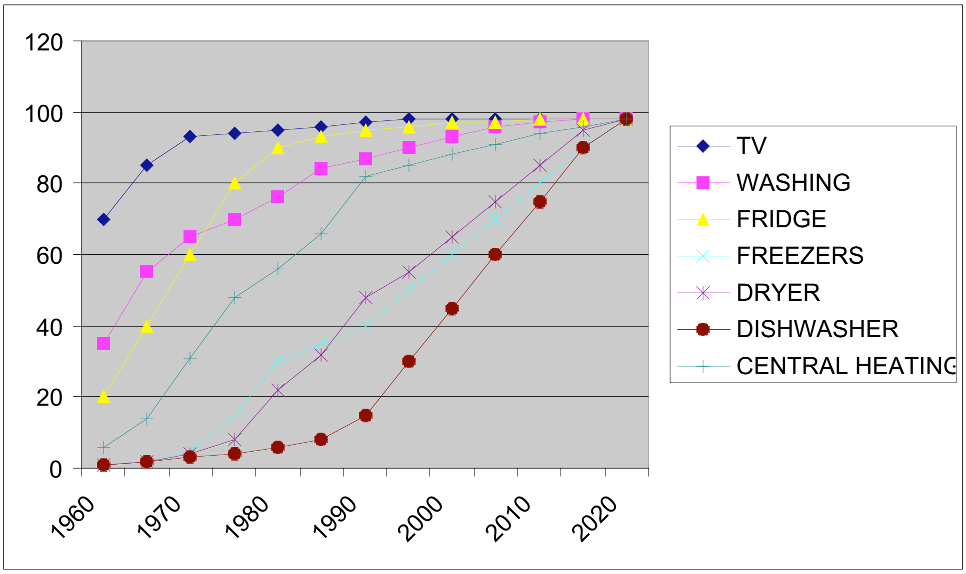

Figure 8.10 Trends in appliance ownership

The national context for this is shown by one of the proposed indicators in the government's strategy for Sustainable Production and Consumption. (See Appendix for definitions of terms)

Indicator 5: 'Material use: Decoupling economic growth from the use of natural resources' Whilst GDP has increased by 28% since 1990, the Total Material Requirement (TMR) has increased by only 7%, the Direct Material Input (DMI) has stayed at a roughly equal level, and Domestic Material Consumption (DMC) has fallen by 10%.

Recent trends show some relative 'decoupling' between TMR and DMI with GDP: but an absolute decoupling between GDP and DMC. Since 1990 GDP has risen steadily whilst the material use indicators have remained roughly constant or falling.

Each of these indicators TMR, DMI, and DMC are derived from the UK Material Flows Account. This records the total mass of natural resources and products that are used by the economy, either directly in the production and distribution of products and services, or indirectly through the movement of materials which are displaced in order for production to take place. It balances the inputs (extraction of natural resourcesfrom the UK environment and imports of goods) with the outputs (wastes, emissions, exports) and accumulation within the economy.

This indicator gives an overall picture of total resource use in both consumption and production. It draws together aspects of many of the other indicators in this report. However, trends should be interpreted with caution. There is no specific resource use target for the UK but there is a commitment to promote continual improvements in resource efficiency, that is to make greater use of the resources extracted.

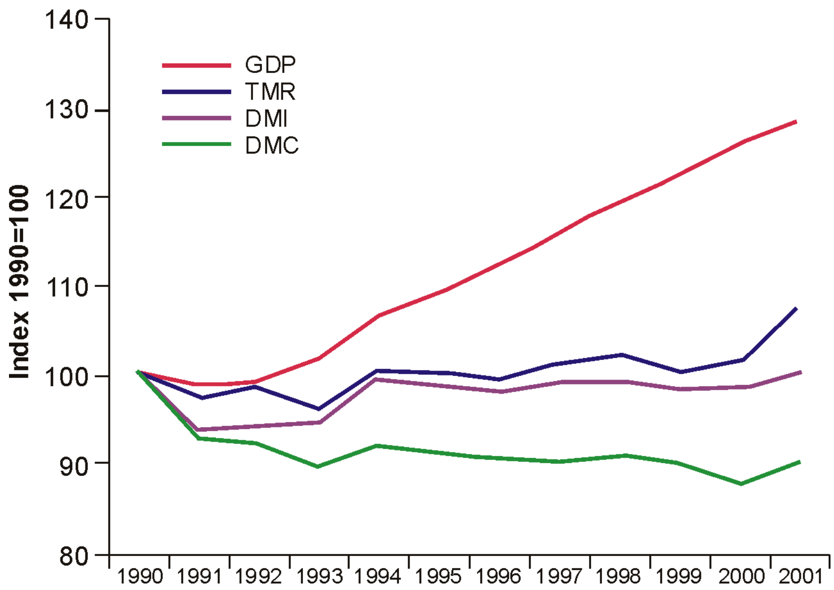

Figure 8.11 Total Material Requirement, Direct Material Import, Direct Material Consumption and GDP in the UK 1990–2001
Source: Office for National Statistics

Scenario indicators and settings

Durable goods are defined here as those with a functional lifetime of more than one year, in contrast to consumables, which are assumed to be consumed in less than a year (these are broad categorisations). Household appliances and similar durable goods each show saturation levels (i.e. one dishwasher per house) and relatively predictable residence times (e.g 10 year lifetime).

In many cases there is an inverse relationship between the efficiency in use, and the turnover of the stock, in that newer models are often more efficient than older stock. For the total EF the effect of increased consumption may be outweighed by the reduction in EF from energy in use, due to increased efficiency of new products. This increased efficiency may itself be outweighed by changes in the product demand: for instance, where the increase in vehicle efficiencies is overtaken by the trend towards powerful SUVs. More detailed projections is pending further analysis of the datasets.

What is harder to predict is the relationship between saturation and ownership, for instance the consumption pattern of televisions is now based around one per room rather than one per house.

The table below shows the main settings taken into the scenario model, with descriptions of the type of effects which are simulated within the model.

Table 8.5.3 Scenario drivers and settings for household durables

	SCENARIO DRIVERS						MAIN SUB-TYPES				
	Stock factors	consumption	production factors	techno-logy factors	activity/ stock	waste factors					
	import %	hh cons/ £income	EF in manuf	EF (energy) in use	turn-over/ stock %	recycling %	large appliances	small appliances	IT	telecoms	radio/tv
F-0 High growth	Hi growth	Hi growth	No change	No change	Hi growth	No change	Growth due to larger houses	Growth due to innovation	Growth due to innovation	Growth due to innovation	Growth due to innovation
F-1 BAU	Slow growth	Slow growth	Small reduct	small reduct	Static	Slow growth	Saturation	Growth due to innovation	Growth due to innovation	Growth due to innovation	Growth due to innovation
F-2 low growth	Static	Static	No change	No change	Low growth	Rapid growth	static	static	static	static	Static
F-4 Factor Four	Slow reduction	Slow reduction	Transformation	Transformation	slow reduction	Rapid growth	Reduct due to sharing	Reduct due to long life	Reduct due to long life	Reduct due to long life	Reduct due to long life

In summary, the main scenario model settings can be structured as follows:

- import %: the proportion of products which are imported: this implies greater travel distances and possible less efficient production;
- hh cons/£income: this is the basic purchasing parameter, i.e. the propensity of households to consume new items, relative to their total income.

- EF in manufacturing: this is an aggregate measure of the efficiency of production:
- efficiency in use: this is relevant to energy-intensive devices, not only kitchen appliances, but also tv and computing with continuous electrical loads.
- turnover/stock %: this is another way to express the 'residence time' or ownership life, this may be determined by functional wear and tear, by aesthetic demand, or by technological innovation as above.
- Re-use and recycling %: this measures the proportion of products discarded or put to one or other form of high-level recovery.

There would be a similar range of scenario settings for durable goods or equipment in the commercial services sector.

Future scenarios

The scenario approach is particularly important for projected futures in household durables sector, which as a sector is less predictable and more open to a wide range of possibilities:

- ***F-0- high growth scenario***: the 'throw-away' economy continues to accelerate, consumers are driven by mass media to work harder and buy more, while houses continue to get larger, there is never enough room to contain all the purchases, and most products become increasingly short life before they go into the waste stream.
- ***F-1: business as usual scenario***: current trends continue with steady growth in purchases of furniture, cars and electrical goods; even when every person is the owner of all common products, and the quality of such products continues to rise, technological improvement means that new items are needed at regular intervals.
- ***F-2: low-growth scenario***: material consumption declines, but mostly for the wrong reasons – economic stagnation, social malaise and environmental disruption. The cost of energy and raw materials goes up: environmental regulations are discarded: imports decline due to international tension. Technological innovation slows down, with the result there is less reason to buy new goods.

F-4: Factor Four scenario

The 'win-win' F-4 scenario sees the quality and efficiency of household durables continue to rise. Equally important, the fixation of consumers on acquisition of new products begins to dwindle, as more people find satisfaction in non-material experiences. Much economic growth begins to take place in the social economy, where sharing, networking, re-use and recycling of goods is a large and growing economic sector.

This social economy works particularly well for larger appliances: washing, lawnmowing and similar items work well when shared on a block basis. IT and telecoms equipment is increasingly shared on a neighbourhood basis, and the incoming wireless/broadband infrastructure has great benefits where networked around a local area. This then provides a common platform for more advanced ICT functions, such as virtual reality (VR) simulation and gaming, sensory VR, real time video and others. In this way ICT turns out to be the renaissance of the community cooperative/network structure.

There is a continuing debate on whether such social economy activity, which happens through a great variety of exchange media, should be 'monetised' or converted into money units. This would make it more visible and less anarchic, but would also constrain much of the most essential activity between friends and neighbours and interest groups.

The main settings and drivers of this F-4 scenario include:

- Import %: the proportion of products imported shows a gradual reduction, as advanced IT-'smart' manufacturing makes localised production ever easier.
- Household consumption per unit of income: this shows a gradual reduction, as households put more resources into quality and home made products, rather than quantity and manufactured products.
- EF in manufacturing: this is rapidly improved, through reduction in transport, process energy and wastage, via customised and batch production. Nano-technology and bio-technology are the keys to enabling this, although each is not without its risks.
- Efficiency in use is also greatly improved, through a combination of regulations, labelling and consumer information, public purchasing policies, supply chain initiatives, and simple levies and subsidies. The effect is to move the future 'average' efficiency towards the present day 'best practice' efficiency levels at about 25% of the average. The results are seen mainly in reductions in household energy demand.
- turnover/stock %: the service economy concept increases the life or residence time for the average product, and reduces the turnover of the stock. This is partly a matter of social demand, and partly through technological advances in component-isation, where for instance phones and computers simply have their cards replaced rather than the whole item.
- Re-use and recycling %: as expected this scenario sees a rapid increase in high level recovery of most product types. Some of this is built into the manufacturing/remanufacturing/service economy approach. Some of this recovery effort is built into new levels of the social economy; for instance some of the problem of youth unemployment is solved by enabling the re-manufacture of electronic devices.

Role of regional policy

Up to now there has been almost zero interest in the issues of consumption from regional policy. At the national level, the government published in 2003 its strategy for 'Sustainable Production and Consumption' (SCP). This is more a review of possibilities than a fixed plan of action, but the main themes include:

- "Taking a holistic approach that considers whole life-cycles of products and services, intervening to deal with problems as early as practicable in the resource/waste flow.
- Working with the grain of markets, and identifying and tackling market failures.
- Integrating SCP thinking and objectives in all policy development and implementation.
- Using a well-designed package of policy measures and following the principles of better regulation.

- Stimulating innovation in all its facets."

The question here is how much this is a regional agenda, and something that the regional organisations can promote. It has to be said that the obvious starting point – consuming less 'stuff' – is apparently opposite to mainstream economic policy and its goal of GDP growth. So the agenda here focuses on potential win-win opportunities:

- Promoting innovation in manufacturing technology, to increase productivity with less impact.
- Encouraging industrial clusters with integrated materials management systems.
- Innovation in materials and waste management, to create markets for re-use, recycling and other forms of recovery.
- Promoting retail clusters and networks which encourage service economies i.e. leasing and hiring for a service level, rather than one-off material purchases.
- Promoting social economy groups and networks for sharing, re-use and recycling, where this is relevant.

8.6 Household Consumables

This section focuses on the material flow and ecological footprint of household 'consumables' – described here as papers, clothes, books, shoes, cosmetics, chemicals, toys, and a boundless plethora of miscellaneous bits and pieces. Each of these product types is either small and diverse, or has an average lifetime in the household of less than 1 year.

Behind the definition lies a very topical question for such items – what is 'consumption' anyway? In the case of food or clothes it is fairly clear. In the case of a visit to the theatre, or the purchase of shares, it is less tangible, and often more difficult to pin down in material terms. What if the consumer buys their clothes at jumble sales, or makes their own Christmas cards, or reads only books from the library? The analysis in this section does not pretend to be full and complete, but it is at least a start in bringing to light the material metabolism of an affluent society, in this region of particular affluence, the South East of England.

8.6.1 Summary of results

- The South East regional direct material consumption (DMC) of household 'consumables' is over 1.75 million tonnes per year, or nearly a quarter of a tonne per person.
- The total material consumption (TMC), including indirect material flows, is six times greater at nearly 12 million tonnes per year. This comprises 5% of the TMC from all activity in the South East region.
- There are a few larger product types by weight: newspapers are 19% of the total, and other paper products over a third. Toilet paper comes in at almost 7% of the total, at around 14 kg per person per year.

- Pet food is almost a quarter million tonnes per year, with a higher than average footprint, due to the highly intensive meat content (bearing in mind that the average UK dog is better fed than the average human in the poorest 20% of the world).
- There is little data available on stocks and turnovers for most items: products such as newsprint tend to pass through the household in a matter of days, whereas clothing and shoes may last a number of years.

Material composition of household consumables

- The main materials in this hugely diverse range of products are dominated by paper based products in newspapers, books, cardboard boxes and chipboard products of every variety.
- Soaps and other household chemicals are 12% of the total, while textiles are 4% of the total by weight.
- Although household consumables are a small proportion of the total by weight, they form a major part of the household waste stream, at over 30%.

Ecological Footprint of household consumables

- The total EF from all consumables is 5% of the total EF from all activity, or 0.37 gha (global hectares) per person.
- The product with the largest single footprint is pet food, with 22% of the total EF. Stationery, newspapers and books together comprise 40% of the total.
- The footprint of wood and pulp-based products such as paper, card and toilet tissue are two thirds 'real land' based. The EF of petfood is about even between 'real land' and 'energy land'.

Trends in household consumables

The demand for consumables is driven by a combination of factors, which are often less predictable and apparently more volatile than with other more fixed sectors:

- Technology: the pace of innovation continues to drive or induce demand, as last year's styles or models fall behind in performance and quality.
- Economics: the relative costs and values for many consumables are changing rapidly, to a point where the material content is almost at zero value compared to the supply chain and logistics content.
- Cultural pressures: fashion and lifestyle are the drivers of the majority of consumption of textiles, and other accessories.

Scenarios for the future

The scenario approach is particularly important for this sector, which is even less predictable than that for 'durables':

- ***F-0- high growth scenario***: the 'disposable' economy continues to drive economic growth. Clothes are bought for a few hours' wear then discarded, while books are downloaded, printed and then shredded in a day. Even where the paper goes back for recycling, the footprint of this intensive consumption pattern continues to rise at 2.5% per year, doubling every 30 years.

- ***F-1: business as usual scenario***: current trends continue the growth in consumption from increasingly global supply chains. There is some measure of corporate responsibility, and current levels of gross pollution and exploitation are reduced. However the continuing spread of affluence puts unremitting pressure on natural resources, which technological improvements such as paper-free newspapers can hardly stem.
- ***F-2: low-growth scenario***: material consumption declines, but again for the wrong reasons – economic stagnation, social malaise and environmental disruption. Costs of natural resources rise as a growing population puts increasing pressure on them: but this has the effect of reducing any kind of environmental management downwards, in a cut and thrust global market.
- ***F-4: Factor Four scenario***: this win-win scenario sees the quality and efficiency of household consumables increase rapidly. Pet food is made on the spot from food waste: clothes are made loose fitting and long lasting, and there is an active recycling market which uses sophisticated databasing to find the right re-used clothing for each individual. Newspapers use neighbourhood based wireless technology to virtually replace paper by digital displays.

Regional policy

Even more than in the case of household durables, household consumables have virtually no place in current regional policy. Again it has to be said that the obvious starting point – ***consuming less 'stuff'*** – is apparently opposite to mainstream economic policy and its overriding goal of GDP growth. Again there are potential win-win opportunities:

- Encouraging industrial clusters with integrated materials management systems.
- Innovation in materials and waste management, to create markets for re-use, recycling and other forms of recovery.
- Promoting retail clusters and networks which encourage service economies, i.e. leasing and hiring for a service level, rather than one-off material purchases, where this is appropriate.
- Promoting social economy groups and networks for sharing, re-use and recycling, for items such as clothes, books, household equipment etc.

8.6.2 Overall MFA–EF results

Scope of consumables

This section includes all day-to-day products that are consumed by households as well as their packaging materials. The list of products comprises things like clothing, footwear, greetings cards, toilet paper, tobacco products, detergents, pet food, books, magazines, plants, etc.. Generally, those 'consumable items' do not last longer than about one year (with some exceptions). For some of these items the average material breakdown could be worked out and was used to calculate the material flow and ecological footprint. The volumes of basic materials is given as an extra information (but must not be double counted with the volumes of products). The numbers for the total in Table 8.6.1 take this double counting issue into account.

There is a similar but less detailed list of consumables in the commercial/public services sector, which is counted in general terms under that heading.

Material flow results

The table below is based on the 'CN' classification with some fairly arcane descriptions. The columns show the proportions of the total of each material type and the EF per capita. Absolute numbers are given in the Appendix.

There is little data available on stocks and turnovers for most items: products such as newsprint tend to pass through the household in a matter of days, whereas clothing and shoes may last a number of years.

- The South East regional direct material consumption (DMC) of household 'consumables' is over 1.75 million tonnes per year, or nearly a quarter of a tonne per person.
- The total material consumption (TMC), including indirect material flows, is six times greater at nearly 12 million tonnes per year. This comprises 5% of the TMC from all activity in the South East region.
- There are a few larger product types by weight: newspapers are 19% of the total, and other paper products over a third. Toilet paper comes in at almost 7% of the total, or 14 kg per person per year.
- Pet food is almost a quarter million tonnes per year, with a higher than average footprint, due to the highly intensive meat content (bearing in mind that the average UK dog is better fed than the average human in the poorest 20% of the world).
- The main materials in this hugely diverse range of products are dominated by paper based products in newspapers, books, cardboard boxes and chipboard products of every variety.
- Soaps and other household chemicals are 12% of the total, while textiles are 4% of the total by weight.
- Although household consumables are a small proportion of the total by weight, they form a major part of the household waste stream, at over 30%.

Table 8.6.1 MFA and EF results for consumable household items in the South East in 2000

CN code	CN description			DMC % of total	TMC % of total	EF % of total	EF per capita (gha/cap)
	Total			1,772	11,604	2,972,745	0.37
6	Live trees and other plants; bulbs, roots and the like;			1%	0%	3%	0.012
23	Residues and waste from the food industries;			13%	20%	20%	0.08
24	Tobacco and manufactured			0%	0%	1%	0.002
30	Pharmaceutical products			1%	1%	1%	0.003
33	Essential oils and resinoids;			1%	1%	1%	0.002
34	Soaps, organic surface-active agents, washing preparations,			7%	3%	3%	0.012
38	Miscellaneous chemical			5%	2%	2%	0.009
39	Plastics and articles thereof			5%	4%	2%	0.007
40	Rubber and articles thereof			0%	0%	1%	0.004
41	Hides and skins	85	9,508	0%	1%	0%	0.001
42	Articles of leather; saddlery and harness; travel goods,			2%	1%	1%	0.002
48	Paper and paperboard; articles of paper pulp,			6%	3%	5%	0.021
49	Books, newspapers, paper products			44%	37%	43%	0.17
Sect. XI	Textiles and textile articles			4%	7%	6%	0.024
50	Silk			0%	0%	0%	0
51	Wool, fine and coarse	36	4,620	0%	0%	0%	0.001
52	Cotton			0%	4%	3%	0.012
54	Man-made filaments			0%	0%	0%	0.001
55	Man-made staple fibres			0%	1%	1%	0.003
61	Articles of apparel and clothing accessories			0%	0%	0%	
63	Other made up textile articles; sets;			1%	2%	2%	0.008
64	Footwear, gaiters and the like; parts of such articles			2%	0%	0%	
70	Glass and glassware			1%	3%	0%	0.002
71	Natural or cultured pearls,			0%	0%	0%	
72	Iron and steel			2%	3%	1%	0.003
76	Aluminium and articles thereof			0%	1%	0%	0.001
90	Optical, photographic, cinematographic, measuring,			0%	0%	0%	0.00008
96	Miscellaneous manufactured articles			4%	4%	3%	0.013
	Other			0%	0%	0%	0.000004
	Totals			100%	100%	100%	0.37

Ecological footprint results

The highest environmental impacts from consumables items come from the consumption of paper and pet food (see Tables 8.6.1 and 8.6.2 above and below). CN code 49 (books, newspapers, paper products) accounts for 46% of the Ecological Footprint of all consumable items (0.17 of 0.37 gha/cap). The other product breakdown in Table 8.6.2 reveals that newspaper and magazines account for the biggest real land EF whereas pet food shows the highest energy land EF.

- The total EF from all consumables is 5% of the total EF from all activity, or 0.37 gha (global hectares) per person.
- The product with the largest single footprint is pet food, with 22% of the total EF. Stationery, newspapers and books together comprise 40% of the total.
- The footprint of wood and pulp-based products such as paper, card and toilet tissue are two thirds 'real land' based. The EF of petfood is about even between 'real land' and 'energy land'.

Table 8.6.2 Energy and real land EF analysis of the consumption of consumable items in households in the South East in 2000

4: Consumables	Energy Land EF	Real Land EF	Total EF	Energy Land EF %	Real Land EF %	Total EF %
Material/Product	Household Consumables			% of total item EF		% of total of category
'000 gha						
Baby equipment	8.58		8.58	100%	0%	0%
Baby toiletries/disposables	56.9		56.9	100%	0%	2%
Books	56.8	91.1	147.9	38%	62%	5%
Clothing	90.7	38.4	129.1	70%	30%	4%
Cosmetics and hair products	18.6		18.6	100%	0%	1%
Detergents, cleaning mat.	143		143	100%	0%	5%
Footwear	26.1	18.7	44.8	58%	42%	2%
HH consumable packaging	155.9	83.6	239.5	65%	35%	8%
Horticultural products	3.62	90.2	93.82	4%	96%	3%
Leather and travel goods	15.9		15.9	100%	0%	1%
Magazines and periodicals	16.1	33.9	50	32%	68%	2%
Medicines	16.6	10.5	27.1	61%	39%	1%
Newspapers and magazines	174.9	369	543.9	32%	68%	18%
Pet food	356	292	648	55%	45%	22%
Photography	0.187		0.187	100%	0%	0%
Soft furnishings	37.4	24.4	61.8	61%	39%	2%
Stationery	191.4	307	498.4	38%	62%	17%
Tobacco	6.15	11.51	17.66	35%	65%	1%
Toilet paper	37.09	129.8	166.89	22%	78%	6%
Toiletries and soap	60.97		60.97	100%	0%	2%
Subtotal EF	1,473	1,500	2973	50%	50%	100%
Subtotal EF per capita (gha/cap)	0.181	0.185	0.366	0.181	0.185	0.366

The proportions of the total EF from consumable items can be boiled down to a shorter list, as in the chart below. This highlights some interesting findings:

- The total EF of pet food is about 6% of the total EF for food consumption.
- The EF of packaging is greater than that of clothes, shoes and similar products put together.
- After the newpapers, the pet foods and the stationery, the toiletries and baby products are the next largest product type, not least because these involve large amounts of pulp which goes straight to waste disposal.

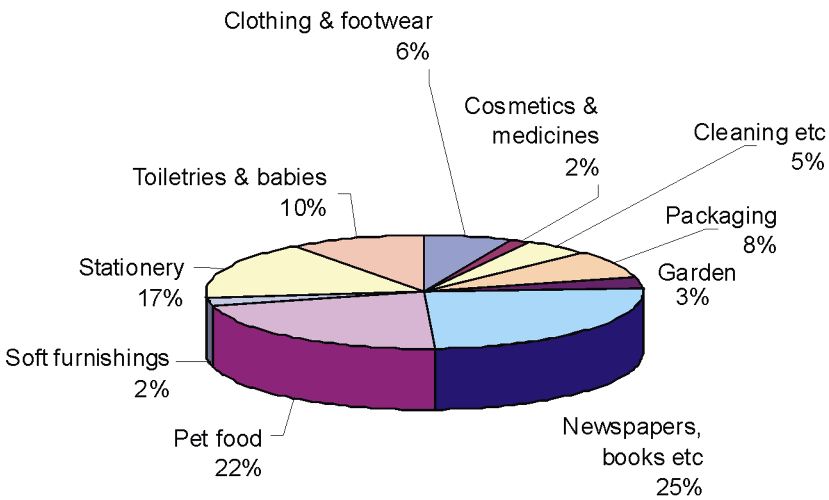

Figure 8.12 EF proportions from consumable items

8.6.3 Trends scenarios and implications

Drivers of consumption

Much of the throughput of consumables is generally driven by the factors of affluence: beyond basic clothing and hygiene lie a complex mix of fashion, lifestyle, cultural habits, health concerns and so on, and in one kind of analysis, simple boredom in a post-industrial affluent society. The trend-based forecasting and modelling approach can hardly deal at all with this very fluid situation, so a more fundamental 'what-if' approach is at least as useful.

Unlike the case with household durables, there is less of a 'saturation' effect – i.e. there is no particular limit to the number of shoes or clothes people will buy, and if there is a lack of physical room for storage then the 'residence time' to disposal will reduce.

There are many retail studies on future products and markets, but only a few look more than a few years ahead at the roots of material consumption:

> *'Britain's average level of happiness is lower than other countries, although we are aware that we are constantly searching for it. We use quick fixes such as holidays and alcohol, however that*

doesn't make us feel better. A new study from The Henley Centre shows that happiness has a different meaning than it once did, and we are constantly seeking to fulfil this with material goods. We feel we don't have the time for things we know make us happy such as relationships and family.' (Henley Centre, quoted in The Times, 20th September 2003).

This can refer to a human needs approach, to identify the different factors at work, shown here in simplified form:[12]

- Physical needs for food, shelter and security
- Emotional needs for community and relationships
- Mental needs for education and culture
- Spiritual needs, aesthetic and identity.

As with the case for household appliances, there are a range of factors which may influence or be influence by these various kinds of human needs:

- Technology: the pace of innovation continues to drive or induce demand, as last year's styles or models fall behind in performance and quality.
- Economics: the relative costs and values for many consumables are changing rapidly, at a time where a digital watch costs less than a loaf of bread. Each of the above needs/demands may be constrained by lack of disposable income, savings or credit. Macro-economic fluctuations will have a large influence on the immediate purchasing ability of consumers, while the underlying trends may be more predictable.
- Cultural pressures: fashion and lifestyle are the drivers of the majority of consumption of textiles, and other accessories.

Future trends and drivers

Future trends depend on 'saturation' and 'turnover', i.e. whether consumption slows down once all households have a particular item, or whether consumers will change their wardrobes and furnishings more often. This is difficult to predict as lifestyle and fashion becomes as strong an influence as functionality, and technological improvement is the main driver of new purchases.

- Past trends show growth in consumption from 1% to 3% per year in various types of materials and products.
- The key question for future trends is 'quantity, quality or experience': if quantity increases then the trends in EF depends on downstream factors of manufacturing and sourcing and imports. If quality increases then material throughput may reduce, while energy intensity or labour intensity may increase. If 'experience' increases then people may rediscover the happiness factors above and do without the objects.
- However there are many consumable items which can be less discretionary and more mandatory, depending on cultural pressures. For instance, freshly pressed formal clothes

[12] Max-Neef 1989: Ekins 1994

serve no particular physical function, in fact they encourage the overheating of office buildings, but they also encourage continuous purchasing and disposal of delicate items.

- The role of technology is also paramount, and often counter-intuitive. For instance laptop computers can effectively replace paper, yet despite rumours of the 'paperless office', paper consumption continues to rise.
- The above drivers of growth are also conditioned by life-cycles and residence times, i.e. how long a product will last in functional terms, or how long it is acceptable in other terms to remain in the stock.
- Saturation effects are generally less influential on consumables than on other types of consumption, in the sense that there is no particular limit to the number of clothes or shoes which can be purchased if the money is there.
- Possibly more important are the 'locational' effects of time, place, composition and convenience: seen at present where the economic retail value of a hot drink is several hundred times its component material/energy values. This 'locational' trend could continue through technological innovation, with the result that economic value and thereby growth, is seen with disposable clothes and other consumables, delivered precisely in time and space to customised specifications.

Scenario settings

Given the wide range of psychological and cultural factors above, there is a need to make simplified 'what-if' assumptions to enable some kind of future projections. The list and the table below shows how a set of scenario trends and drivers can be structured in very basic terms.

- Import %: the proportion from imports and the continent of origin.
- Household consumption relative to income (hh cons/£income): the elasticity of consumption as a function of disposable income growth. This could be counted as income after housing/commuting costs or some other measure.)
- EF in manufacturing: this is a very aggregated figure representing the overall intensity of complex material supply chains in textiles, paper and other features.
- 'Efficacy' factor: this is an innovative feature which aims to represent something of the perceived satisfaction, utility or welfare derived from the consumption of any particular class of items. For instance it is clearly the case that the value of clothing depends not only on its function but on its aesthetic, cultural and symbolic appeal. Retail activity is now seen as much as 'therapy' as anything more substantial. The point here is that it may be possible to provide greater satisfaction with less material throughput, and the adjustment of this factor can reflect that.
- Packaging %: this is fairly obvious, except where related to the note on efficacy, in the sense that the packaging becomes part of the product.
- Recycling %: this is an aggregated figure which represents an average of the different levels of re-use, re-manufacture, high and low level recycling, and so on.

Table 8.6.3 Scenario settings for household consumables

	SCENARIO DRIVERS						MAIN SUB-TYPES				
	Stock factors	consu mp tion	product ion factors	technol ogy factors	activity/ stock	waste factors					
	Import %	hh cons/ £ income	EF/ t manuf	Efficac y <>	pack-aging %	Recyc-ling %	tobacco etc	clothing/ footware	house-hold effects	Personal & pharmac eutic	literature/ other
F-0 High growth	Rapid growth	Rapid growth	Growth	Rapid reduc-tion	Growth	Reducti on	Rapid growth	Rapid growth	Rapid growth	Rapid growth	Rapid reduc-tion
F-1 BAU	Growth	Growth	Stable	Rapid reduc-tion	Stable	Stable	Growth	Growth	Growth	Growth	Stable
F-2 low growth	Stable	Stable	Stable	stable	Rapid reduc-tion	Growth	Stable	Stable	Stable	Stable	Rapid reduc-tion
F-4 Factor Four	Rapid reduc-tion	Rapid reduc-tion	Rapid reduc-tion	rising	Rapid reduc-tion	Rapid growth	Rapid reduc-tion	Rapid reduc-tion	Rapid reduc-tion	Rapid reduc-tion	Rising

Future scenarios

An exploratory 'what-if' approach is particularly important for this sector, which is even less predictable that that for 'durables':

- ***F-0: high growth scenario***: the 'disposable' economy continues to drive economic growth. Clothes are bought for a few hours' wear then discarded, while books are downloaded, printed and then shredded in a day. Even where the paper used goes back for recycling, the footprint of this intensive consumption pattern continues to rise at 1–2% per year, with a doubling of the total by 2050.
- ***F-1: business as usual scenario***: current trends continue the growth in consumption from increasingly global supply chains. There is some measure of corporate responsibility, and current levels of gross pollution and exploitation are reduced by concerted efforts on environmental regulation. However the continuing spread of affluence puts unremitting pressure on natural resources, which is hardly stemmed by technological improvements such as paper-free newspapers.
- ***F-2: low-growth scenario***: material consumption declines, but again for the wrong reasons – economic stagnation, social malaise and environmental disruption. Costs of natural resources rise as a growing population puts increasing pressure on them: but this has the effect of reducing any kind of environmental management downwards, in a cut and thrust global market. With a lack of investment capital, older less efficient production continues, and the net effects on the total footprint are only a slow reduction.

F-4: Factor Four scenario

This 'win-win' scenario sees the quality and efficiency of household consumables increase rapidly. More significantly, the general welfare per unit of material consumption increases, as people derive greater happiness from fewer objects.

- Pet food is made on the spot from food waste; newspapers use neighbourhood based wireless technology to virtually replace paper by digital displays.
- The social economy enable a rapid growth in networks for sharing of many consumables. For instance, clothes are made loose fitting and long lasting, and there is an active recycling market which uses sophisticated databasing to find exactly the right item of re-used clothing for each individual.
- Following that example through, many clothing types are transformed from being disposable industrial commodities driven by fashion, to individualised art objects where personal engagement in their production is the key to satisfaction and value.
- The economy as a whole is shifted from one of low value production/disposal to high value closed loop re-use and re-manufacturing. There is a rapid shift of economic activity into the social economy: on paper GDP and similar indicators appear to be at almost zero growth, but the 'real economy' of human welfare is booming as never before.

Implications for regional policy

Even more than in the case of household durables, household consumables and their environmental impacts have virtually no place in current regional policy. Again it has to be said that the obvious starting point – ***consuming less material products*** – is apparently opposite to mainstream economic policy and its overriding goal of GDP growth.

The extract of retail analysis here is written in terms of food, but could apply equally to other commodities – organic beauty products, paper products, paints and many others.

> *"Quality-seekers, currently the minority among organic consumers, are the segment that manufacturers should focus their attention on. The market for organic products in the UK is at a turning point. In order for it to survive – and thrive – organic manufacturers need to appeal to consumers' selfish motivations, rather than their concern for social and environmental issues.*
>
> *According to strategic marketing consultancy The Henley Centre, the number of consumers who buy organic products decreased from 58% in 2000 to 40% in 2002. This finding is corroborated by, among others, the Food Standards Agency, who found in 2002 that 5% of consumers have given up on organic products; this is on top of the 38% who have never tried organics at all."*

However the challenge is to demonstrate to a wide range of players – producers, designers, distributors, purchasers and final consumers, the range of potential benefits in sustainable production and consumption:

- Economic benefits in new markets, improved shareholder value, reduced risk, more competitive operations, waste minimisation.

- Environmental benefits are at both the local, regional and global scale.
- Social benefits should be apparent in better distribution of resources, better links with international development, improved cohesion through social economy activity, and opportunities in training/ skills development and intermediate labour markets.

In very practical terms, and against the mainstream in regional policy, there may be potential win-win opportunities:

- Regional ‘green’ investment bank which promotes environmentally efficient production and distribution.
- Public sector purchasing consortia: the combined public sector spend in the South East region is in the order of £60 billion, of which ‘consumables’ are in the order of £6 billion. If this level of spending is mobilised and coordinated, then there are huge opportunities for building up supply chains in environmentally friendly goods, which then enable new markets from consumers.
- Encouraging industrial clusters with integrated materials management systems for recycling, re-manufacturing.
- Innovation in materials and waste management, to create markets for re-use, recyclingand other forms of recovery.
- Promoting retail clusters and networks which encourage service economies i.e. leasing and hiring for a service level, rather than one-off material purchases, where this is appropriate.
- Promoting social economy groups and networks for sharing, re-use and recycling, for items such as clothes, books, household equipment etc.

8.7 Transport

Mobility is the basis for modern lifestyles, and transport is the 'maker or breaker' of cities and regions. But the transport system is increasingly dysfunctional: it is breaking local and global environmental limits, and future trends are set to bring the system itself to a halt. The long-standing link between economic growth and transport growth has somehow to be 'de-coupled'.

Most people now agree on this – but would prefer to see others' travel restricted before their own. The 'predict and provide' philosophy is over in the UK, at least in principle, and there is a new generation of local transport plans and partnerships for an 'integrated' transport system. But will this be enough to contain the inexorable demand and desire for mobility? It is relevant that the main high street of the South East region – the M25 – is the most seriously over-loaded piece of the national infrastructure. We cannot provide all the answers here for this hugely controversial question – but we do aim to build bridges between the no-win trends of 'business as usual', and the win-win opportunities of a Factor 4 future.

8.7.1 Summary of results

- The average distance travelled on all forms of surface transport was 13,100 km per person per year, or 36 km per day per person: 85% of the distance was by car, 6% by rail, and 3% by bus. This figure divides into those people with very localised lives – the old and the young – and others who travel much more.
- Half of all journeys are for leisure/personal business, and two thirds if shopping is included. Commuting and business are 23% for males and 15% for females.
- 83% of households have at least one car or other vehicle, and 37% have two.
- The average person in the South East travelled 7,600 km by air per year: 97% of this was international travel, and 26% of this was within the EU.
- For walking the reported figure is 303 km per person – less than half a mile per day (although there are questions on how this is measured). Cycling, the most energy efficient mode of all transport, is an average 74 km per person per year, or one mile per week per person. Given these trends it is not surprising that obesity is a growing problem.

Material flows in the transport system

- Passenger transport in the South East used a total of over 6 million tonnes of (fossil) fuels. The majority of this is used by cars (53%) and planes (39%). If hidden flows are included the total material flow is 6.9 million tonnes or 850 kg per person per year.
- The result of the combustion of this amount of fuels was CO_2 emissions of over 24 million tonnes per year (3 tonnes per South East resident).
- Air travel (for South East residents) used a total of 2.5 million tonnes of oil, with CO_2 emissions of 7.9 million tonnes per year.
- The reliance on fossil fuel oil is likely to change with the new technologies including gas, vegetable oil, hydrogen, electrical power, and various hybrids of these.

EF of transport system

- Transport as a sector is centred on the consumption of fossil fuels, the resulting carbon emissions, and their direct relationship with the footprint. Other effects such as 'real land' and other greenhouse gas emissions are a small percentage of the total.
- The total EF of surface travel is 0.53 gha per person, of which 92% is from cars. The total EF of air travel is 0.25 gha per person per year.
- The total EF from all passenger transport is 0.78 gha per person, or 11% of the total aggregated EF for the region. This number includes the environmental impacts of the manufacture and maintenance of cars.
- The relative efficiency of different modes is the key: taxis are by far the least efficient (assuming one-way trips), followed by short-haul air and petrol cars. Long distance coach, rail and long distance flights are relatively efficient. The net effect of course depends on the distance travelled, which in the case of air travel, can be very large.

Freight transport

- The total EF of freight transport is 0.6 gha per person, or three quarters of the total for passenger transport. This includes distribution within the South East region and UK transports as well as imports destined for consumption in the South East. (This category is accounted for elsewhere in the embodied energy and EF of manufactured goods.)

Trends in transport

- Trends and projections in transport are the subject to many engineering models and policy studies. In recent decades the overall demand for surface transport has been closely linked to economic growth at 2–2.5% growth per year (i.e. a 30–40 year doubling time). Most 'business as usual' projections continue these trends.
- Light commercial transport is growing at a faster rate than passenger, at . 3–3.5% per year.
- Air travel is growing at the unprecedented rate of 5–6% per year, with a doubling time of less than 15 years.
- Increasing the rate of growth are affluence/lifestyle factors, technology improvements, the falling price of fuel, and induced demand, for instance from internet-enabled business activities and social networks.
- Restricting the rate of growth are physical limits and infrastructure congestion; time constraints on the part of consumers and businesses; government pricing and fiscal policies; and not least, environmental objectives which may encourage regulation and market measures.

Scenarios for the future

The scenario approach is well established in transport studies, which combines the engineering approach with a more volatile 'lifestyle' approach:

- ***F-0: high growth scenario***: unrestricted growth in travel demand, and privatisation of networks and infrastructure.
- ***F-1: business as usual scenario***: continuation of current trends, with an uneasy balance between economic, social and environmental objectives.
- ***F-2: low-growth scenario***: decline in the rate of growth through economic slowdown and social division. Climate change, international terrorism and fuel shortages disrupt networks and infastructure.
- ***F-4: Factor Four scenario***: a win-win scenario based on integration of networks, coordination of supply and demand, accelerated technology improvements, and demand side management.

Regional policy

Transport can be seen as an endemic contradiction in late-industrial society, which national and international governments appear to be powerless to solve. It is not surprising that the South East region does not possses hardly a fraction of the resources to provide real solutions. However there are various kinds of enabling measures which might be combined with some tangible influence on what are otherwise problematic trends:

- a multi-sectoral sub/regional integrated transport strategy would use the combined weight of public purchasing for bargaining power, expertise and added value
- incentives for clean technology
- diversification of ownership and access
- integration of diverse networks
- coordination of supply and infrastructure with journey demand and cultural mobility
- use of ICT as the catalyst for integration, diversification and coordination
- demand management, social economy networks for car and lift sharing, green travel plans, coordination of public transport

8.7.2 Overall MFA–EF results for the region

Scope and definition

The transport figures are based on ‘residence’, in other words how far an average resident of the South East region travels per year. For surface transport there will be small differences between these figures, and the actual amount of through travel and commuting within the regional boundary. For air travel there will be major differences, depending on how this is measured: Heathrow for instance, is still the largest international hub in the world, and over 60% of its passenger movements are simply in international transit.

The EF factors are based on travel per person, whether driver or passenger, and so include information on the average occupancy of different modes. The manufacture and maintenance of vehicles is also included in the EF factors. It is also included in the household ‘durables’ section 3.7, where it can be seen more in more detail. This double counting is then corrected in the aggregated regional MFA-EF footprint accounts. For air travel, the figures include the holiday accounts which is given in more detail in Chapter 3.2.

Material flow results

The overall picture for transport in the South East region includes passenger transport and freight transport within the South East as well as imports to the South East. However the calculation of embodied transport energy and EF of materials and products (e.g. with food or aggregates), is to be seen as supplementary information: this is not double counted in the aggregated results tables.

General results

- The average distance travelled on all forms of surface transport was 13,100 km per person per year, or 36km per day per person: 85% of the distance was by car, 6% by rail, and 3% by bus. This figure divides into those people with very localised lives – the old and the young – and others who travel much more.
- Half of all journeys are for leisure/personal business, and two thirds if shopping is included. Commuting and business are 23% for males and 15% for females.
- 83% of households have at least one car/other vehicle, and 37% have two.
- The average person in the South East travelled 7,600 km by air per year: 97% of this was international travel, and 26% of this was within the EU.
- For walking the reported figure is 304 km per person – less than half a mile per day (although there are questions on how this is measured). Cycling, the most energy efficient mode of all transport, is an average 74 km per person per year, or one mile per week per person. Given these trends it is not surprising that obesity is a growing problem.

Table 8.7.1 EF results for passenger transport

Mode of passenger transport	Total pkm by all SE residents	Specific EF	EF due to GHG emissions	Built land EF	Total EF	Total EF per capita	Percentage of total travel	Percentage of total EF	Average travel km / person
	[billion (10^9)pkm]	[global m^2 /1000 pkm]	['000 gha]	['000 gha]	['000 gha]	[gha/cap]	%	%	['000 km]
International air travel	60.1	293	1,958	13.0	1970	0.243	97%	94%	7513
Domestic air travel	1.8	472	86	1.0	86	0.011	3%	6%	226
Total air travel	61.9	765.0	2044	14.1	2058	0.25			7739

Walking	2.5	-	-	-	-	-			308
Bicycle	0.6	0.3	0	0.01	0	0.000	1%	0%	75
Private hire bus	0.6	334	19	0.00	19	0.002	1%	0%	70
Car	90.6	777	3963	0.88	3964	0.488	85%	92%	11325
Motorcycle/moped	0.2	436	7	0.00	7	0.001	0%	0%	20
Van/lorry	1.1	777	48	0.01	48	0.006	1%	1%	141
Other private	0.1	455	6	0.00	6	0.001	0%	0%	18
Local bus	1.8	334	61	0.00	61	0.008	2%	1%	228
Non-local bus	1.0	170	16	0.00	16	0.002	1%	0%	120
Surface Rail	6.7	174	116	0.05	116	0.014	6%	3%	836
Taxi/minicab	0.8	808	66	0.02	66	0.008	1%	2%	101
Other public (incl ferries, light rail etc)	0.4	334	15	0.00	15	0.002	0%	0%	55
									0
Total surface travel	106.4		4317	0.97	4318	0.532	0.977	100%	13296
									0

Material flows in the passenger transport system

For the consumption of basic materials only 'energy carriers' are taken into account, i.e. there is only one entry to the CN list under code 27: "Mineral fuels, mineral oils and their products". Hence the CN material flow table below is very simple.

Table 8.7.2 MFA and EF results for transport services in the South East in 2000

MFA / EF	CN code	CN description	Passenger Transport	Freight Transport	Unit
Direct Material Consumption (DMC)	27	Mineral fuels, oils and products	6.26	5.98	Mt
Total Material Consumption (TMC)	27	Mineral fuels, oils and products	6.87	6.05	Mt
CO_2 Emissions	27	Mineral fuels, oils and products	23.95	18.88	Mt
Ecological Footprint (EF)	27	Mineral fuels, oils and products	6.41	4.98	Mgha
EF per capita	27	Mineral fuels, oils and products	0.78	0.61	gha/cap

Freight transport

The total EF of freight transport is 0.61 gha per person, or three quarters of the the total for passenger transport. This includes distribution within the South East region and UK transports as well as imports destined for consumption in the South East.

Ecological footprint results

Transport as a sector is centred on the consumption of fossil fuels, the resulting carbon emissions, and their direct relationship with the footprint.

- The total EF of surface travel is 0.53 gha per person, of which 92% is from cars. The total EF of air travel is 0.25 gha per person per year.
- The total EF from all passenger transport is 0.78 gha per person, or 11% of the total aggregated EF for the region.

Real land area requirements are very small compared to energy land and were not calculated for freight transport separately (see Table 8.7.3). The highest impact comes from the use of cars followed by air travel (see Chapter 3.2 for details).

Table 8.7.3 Energy and real land EF analysis of passenger and freight transport in the South East in 2000

7: Transport Services	Energy Land EF	Real Land EF	Energy Land EF	Real Land EF	Unit
Material/Product	Passenger transport		Freight transport		
Air travel - all services	2,044	6.41	-	-	‘000 gha
Bicycle	0.0093	0.394	-	-	‘000 gha
Private hire bus	18.8	0.033	-	-	‘000 gha
Car	3,963	40.1	-	-	‘000 gha
Motorcycle/moped	6.86	0.099	-	-	‘000 gha
Van/lorry	48.41	0.500	-	-	‘000 gha
Other private	6.24	0.061	-	-	‘000 gha
Local bus	60.8	0.106	-	-	‘000 gha
Non-local bus	16.4	0.041	-	-	‘000 gha
Surface Rail	116.1	2.26	-	-	‘000 gha
Taxi/minicab	65.57	0.75	-	-	‘000 gha
Other public	14.6	0.025	-	-	‘000 gha
Freight transport	-	-	4,976	-	‘000 gha
Subtotal EF	6,360	50.8	4,976	-	‘000 gha
Subtotal EF per capita	0.784	0.006	0.613	-	gha/cap

The relative efficiency of different modes is the key: taxis are by far the least efficient (assuming one-way trips), followed by short-haul air and petrol cars. Long distance coach, rail and long distance flights are relatively efficient. The net effect of course depends on the distance travelled, which in the case of air travel, can be very large indeed. If some kind of assessment of performance, comfort, convenience and personal space is included, then of course a large car can score highly in comparison to a crowded bus.

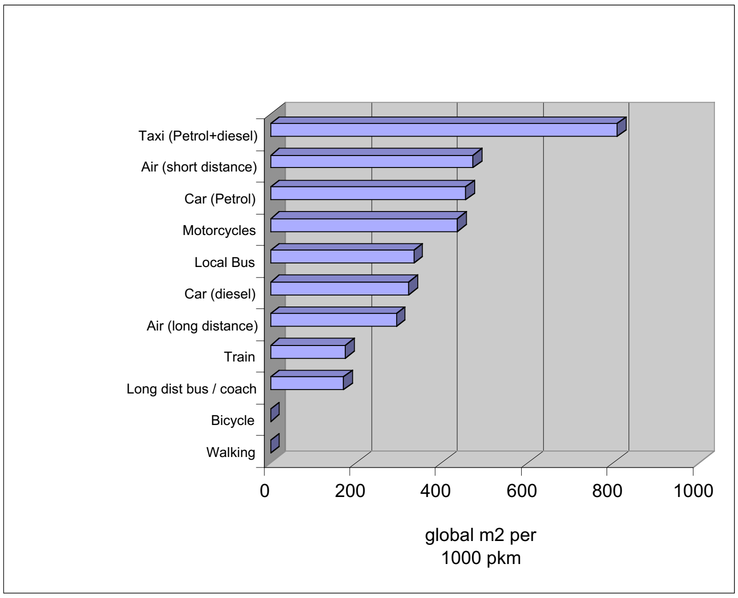

Figure 8.13 Relative EF factors of main transport modes

8.7.3 Trends, scenarios and policy implications

Future trends and drivers

Trends and projections in transport are the subject to many engineering models and policy studies. The current forecasts in traffic growth are consistent with recent evidence, despite the government's goals in the 10 Year Strategy for transport.

- In recent decades the overall demand for surface transport has been closely linked to economic growth at 2–2.5% growth per year (i.e. a 30–40 year doubling time). Most 'business as usual' projections continue these trends.
- Light commercial transport is growing at a faster rate than passenger, at 3–3.5% per year.
- Air travel is growing at the unprecedented rate of 5–6% per year, with a doubling time of less than 15 years.
- Increasing the rate of growth are affluence/lifestyle factors: technology improvements: the falling price of fuel: and induced demand, for instance from internet-enabled business activities and social networks.
- Restricting the rate of growth are physical limits and infrastructure congestion; time constraints on the part of consumers and businesses; government pricing and fiscal policies; and not least, environmental objectives which may encourage regulation and market measures.

In terms of projecting these trends, a very simplified set of transport scenario trends and drivers can be structured as follows:

- Vehicle occupancy: basically, the higher the occupancy, the less the vehicle movements and the greater the efficiency. This occupancy factor will be influenced by technology, information systems, demand management, green travel plans and so on.
- Passenger travel demand intensity (economic): this is an overall measure of the linkage or 'decoupling' of economic growth from travel demand.
- Public transport proportion of all transport: this is the holy grail of the 'modal shift'; this works at different geographical scales, e.g. rapid shift in Central London, but much more difficult in the diffused economy and social networks of the South East, where orbital and cross-country movements are dominant.
- Vehicle energy efficiency: subject to fuel and engine regulations and fiscal measures at UK and EU levels.
- Vehicle new/exg stock: i.e. the turnover effect, size of the stock, and any effects on vehicle efficiency which may be higher in new vehicles.
- Alternative fuels percentage. This includes a complex set of combinations and transformations from one medium to another: gas, renewable oil, hydrogen and other forms of electric power.

Table 8.7.4 Scenario settings for transport (passenger and freight)

	SCENARIO DRIVERS						MAIN SUB-TYPES				
	Stock factors	consump-tion	produc-tion factors	techno-logy factors	activity / stock	waste factors					
	veh. occupancy	pass travel demand	public %	veh energy eff	veh new / exg stock	alternative fuels%	car	public	air	Lorry freight	Other freight
F-0 High growth	Reduc-tion	Rapid growth	Reduc-tion	Reduc-tion	Growth	Reduction	Rapid growth	Reduc-tion	Rapid growth	Rapid growth	Reduc-tion
F-1 Business as usual	Stable	Growth	Stable	Stable	Stable	Stable	Growth	Stable	Growth	Growth	Stable
F-2 low growth	reduction	Stable	Reduc-tion	reduction	reduc-tion	Growth	Stable	Reduc-tion	Stable	Stable	Reduc-tion
F-4 Factor Four	Rising	Reduction	Rising	Rising	Rapid reduc-tion	Rapid growth	Reduc-tion	Rising	Reduc-tion	Reduc-tion	Rising

Future scenarios

The scenario approach is well established in transport studies, which combines the engineering approach with a more volatile 'lifestyle' approach.

F-0- high growth scenario: Transport is increasingly privatised and there is a new generation of large scale road building on private finance lines. There are some new forms of public transport such as light rapid transit, and high speed links between the growing network of regional airports, and the latter require much cutting and filling to ensure smooth routes. Car parks are often built underground, and in urban centres there is a trend towards connecting tunnels to link one car park to another.

A market driven approach to transport sees increased differential access to roadspace and public transport. Congestion charging and area or route charging is commonplace, and there is no perceived problem with rationing access by the ability to pay. This helps to polarise communities in new developments and urban hubs into those with car-based individualised access, those with collective investments in public transport connections, and the residuals without any particular accessibility at all. The ability of big business to make big investments is seen in the increasing scale and integration of transport and development, regionally, nationally and globally. For instance the new generation of mixed urban villages with built in transport links are then replicated with floating airports/shopping/retirement villages.

F-1: business as usual scenario: A planned management of integrated transport on both supply and demand sides results in a very sophisticated system, where users and providers are in continuous networked contact. The effect is to enable a doubling of traffic in all modes over the 50 years, while air traffic multiplies by 5 times. While the public policy objective was to support public transport, private cars still show a greater facility for self-organising systems, and now that congestion management and differential pricing can be organised in real time, the benefits of car travel are even greater. However the widespread sharing and leasing of cars is widely available as a quasi-public service, while the digital surveillance which pervades public and private modes raises fears and opposition to loss of civil liberties. The ultimate prize then becomes a private car which is dis-connected from automatic traffic management and positioning systems, so the wealthy pay large sums for the privilege of sitting in traffic jams with full-immersion cyber-net fantasy games.

For transport infrastructure, a planned management on both supply and demand sides results in a very sophisticated system, where users and providers are in continuous networked contact. While the public policy objective was to support public transport, private cars still show a greater facility for efficient 'self-organising' systems, and now that congestion management and differential pricing can be organised in real time, the benefits of car travel are even greater. The London Congestion Charging scheme now extends over most of the South East region, but of course the complex pattern of charges for urban centres and for motorway links has helped to redistribute not only traffic but commercial activity right across the region.

F-2: low-growth scenario: The defensive stance of many territories and communities continues the state of the transport system as a huge problem for everyone concerned – users, providers, financiers and neighbours. Congestion soon reaches the point at which it is self-regulating, so car manufacturers in response continue the trend towards self-containment, with mobile in-car leisure, lifestyle and work facilities improving all the time. The sealed environment approach is also reinforced by worsening hazards and associated paranoia. The result is that many live spend hours and days in gridlock on major routes, in a lifestyle of slow but in continuous mobility. Air travel also continues to double every 15 years as environmental hazards create restlessness, paranoia, displacement and migration for large populations.

F-4: Factor Four scenario:

This 'win-win' scenario sees the quality and general efficiency of transport increase rapidly: the welfare from each unit of mobility increases, as people derive greater happiness from less travel in a more localised lifestyle.

Integrated accessibility (walking, cycling, train, bus, multiple occupancy, single occupancy) is the basis for new development. Some changes occur through new strategies of existing organisations, for example the major supermarkets contribute to the dispersal into smaller outlets, with greater centralisation for efficient management of supplies. As banking services shift to the internet traditional clusters of local shops built around the bank disappear, replaced by other services, such as over the counter treatment centres, and community virtual reality points.

The demand for travel is stabilised and in some areas actually reduces, as more people live and work locally, and local communities offer more in the way of cultural identity. Unfortunately one of the effects is a rapid worsening of the transport system, as many inner city areas declare UDI on major roads which cut up their neighbourhoods, and the 'Reclaim the Streets' movements are a major political lobby. The general congestion actually serves to worsen emissions even while total mileage is reduced. While all residential streets are converted to pedestrian zones, there is rapid re-arrangement of property values to favour areas not adjacent but very nearby to the urban transport hubs.

However air travel continues to grow, albeit at a slower rate than at present, as one of the features of the community-oriented society is the desire to share cultures and kinship networks which are increasingly global.

Scenario modelling

The net effect of each of the above scenarios can be seen modeled on the SE-MB scenario model system. Although the system projects by decades up to 2050, the 2020 figures are shown here as this represents some kind of practical horizon.

Table 8.7.5 Scenario model of transport system: results in 2020 (provisional version)

	Transport Summary Table	UNIT	2000	F-0	F-1	F-2	F-4
POP / GDP		million	8.0	8.5	8.6	8.5	8.2
	Total GDP	£ bn	110.0	210.9	176.4	157.3	151.1
	GDP per head	£1000/cap	13.7	24.8	20.4	18.5	18.5
	industry/primary	£bn	19.8	-48.6	-23.9	0.0	0.0
	Commerce & public	£bn	90.2	259.5	200.3	157.3	151.1
INTENSITY							
	pass.travel intensity	km/y/£GDP	7580	7137	6967	6856	6856
	freight intensity/change	Mt.km/y/£GDP	0.31	0.35	0.34	0.29	0.29
	average occupancy	% change					
PRIVATE							

	car/mcl	PJ/year	226.6	385.0	256.9	195.6	175.7
	electric/other	PJ/year	1.8	21.2	11.5	9.7	27.1
	cycle/walk>1km	PJ/year	0.0	0.1	0.1	0.1	0.1
	bus/taxi	PJ/year	2.0	6.2	10.8	6.0	4.9
	gas/other bus	PJ/year	0.0	1.8	1.3	1.3	1.6
	LRT	PJ/year	0.0	5.9	4.4	4.5	5.3
	train local/national	PJ/year	8.1	9.8	15.6	17.0	13.8
	TOTAL SURFACE	M km/year	104127	188031	153443	134699	129428
	total pass.trans.energy	PJ/y	238.5	430.0	300.6	234.2	228.5
AIR							
	total pass.travel	M.km/y	61974	123948	123948	123948	123948
	total final energy	PJ/y	130.1	154.9	154.9	154.9	154.9
	surface travel generated	M.km/y	1600	3200	3200	3200	3200
FREIGHT							
	Air	PJ/year	10.0	51.4	34.0	26.4	14.5
	diesel lorry	PJ/year	65.3	105.7	69.5	54.1	35.1
	gas/other lorry	PJ/year	0.5	9.8	21.9	6.2	77.1
	Rail	PJ/year	1.7	2.2	5.1	5.7	5.5
	water/pipeline	PJ/year	2.5	3.6	1.9	2.4	-5.8
	TOTAL FREIGHT	Mt.km	34350	72780	59433	46256	44446
	total final energy	GJ	80.0	172.6	132.5	94.9	126.4
DELIVERED ENERGY							
P	electric/other	PJ/year	9.9	37.0	31.5	31.2	46.2
G	Gas	PJ/year	0.5	11.6	23.2	7.6	78.7
O	Oil	PJ/year	438.2	709.0	533.3	445.3	385.0
	TOTAL DEMAND		448.6	757.6	588.0	484.0	509.9
CARBON		mtCO_2					
G	Gas		0.0	0.7	1.40	0.46	4.76
O	Oil		37.0	59.8	44.97	37.54	32.45
C	Coal		0.0	0.0	0.00	0.00	0.00
	Renew		0.0	0.0	0.00	0.00	0.00
P	POWER		1.5	4.5	3.86	3.82	5.67
	total CO_2 from transport incl power		38.54	65.03	50.24	41.83	42.89
ECOLOGICAL FOOTPRINT							
	Car	million gha	5.1	9.2	6.1	4.7	4.8
	public transport	million gha	0.4	0.7	0.9	0.8	0.8
	Air	million gha	3.0	3.5	3.5	3.5	3.5
	freight	million gha	1.9	3.8	2.9	2.1	2.4
	TOTAL	million gha	10.3	17.2	13.4	11.2	11.5

Implications for regional policy

As in other sectors, it is clear that the main agenda for transport strategy will be constructed on a range of social and economic objectives, and it is to be hoped that environmental and resource objectives can be combined as a spin-off or win-win case. The regional transport strategy is a kind of bridge head between national level policy/taxation, and sub-regional/local transport investment. In that sense it shows a good range of aspirational policies, with no targets by which it could be measured.

Any transport strategy will naturally be focused on social and economic objectives, and the MFA-EF result are at best an aspirational spin-off. For instance the ecological footprint of a typical car/light van through its life cycle can be summarised (Chapter 3, table 3.3):

- Fuel combustion: 70%, of which $C0_2$ emissions are 99.75% of the total
- Manufacture and maintenance: 30%
- Road/parking area: negligible

This is very revealing in the sense that improvements to occupancy (usage) and fuel efficiency, will on aggregate have twice the effect of any changes to ownership and manufacturing of the physical item. In other words, the government advice that ownership was preferable to useage, still stands. It is also revealing that comparison with other modes shows that, passenger mile for mile, air travel, motorcycles and local bus travel are comparable with the EF ratios for private cars.

However this calculation is on a global scale; on a regional and local scale, the physical presence of roads and parking is very much an issue.

Vehicle emissions controls relate mainly to NO_x , particulates and other pollutants, which have very little influence on the EF. Current EU targets are to increase the carbon/fuel efficiency of cars by 30% from 1996/2010. This is being partly undermined by the recent trend for more powerful SUV type vehicles. There are no practical known technologies which can increase significantly the efficiency of air travel, assuming that current speeds are predominant (which rules out helium balloons).

The effect of the current trend forecasts (business as usual), on the relative EF factors of the dominant modes, car travel and air travel shows, that while long distance air at present is relatively 30% more efficient, and car travel is 50% greater in volume, its much higher rate of growth increases to outweigh car travel soon after 2021. The continuation of this trend line after 2031 is a matter for speculation.

Role of transport in the Factor 4 scenario

Overall, the current evidence appears to show huge difficulties in even slowing the rate of growth in transport demand. The majority of external pressures are against any such constraints, and rather encourage the spread of travel to social groups which at present are relatively localised – the old, the young, the sick, differently abled and the less affluent.

Physical constraints of road and parking infrastructure may be as effective as anything else in restraining demand, particularly as no national governments seem prepared to raise the cost of private motoring. However technological improvements may soon overcome these.

Even the Factor 4 scenario recognises that international travel is likely to be maintained and possibly increased, and that there are huge economic and social benefits in this.

The implication is for some level of tradeoff between the transport sector, where F-4 type reductions are very difficult, and other sectors, where F-4 reductions are much easier. Direct energy to buildings in particular is one where rapid reductions are possible and desirable for all parties involved.

8.8 Construction

Cities have always been the hubs for their hinterlands, as those in the centre tend to organise and exploit those on the periphery. But the South East region is a unique case in the UK – the richest and largest region, the hinterland for Greater London, but also in many ways the 'edge city' for the conurbation, with better connections, faster growth, higher quality of life and so on. At the same time it is large and diverse, crowded and congested, beautiful and despoiled, with huge opportunities and problems in its built environment. What we see in this built environment – the urban form and fabric – is a direct result of these dynamics.

This chapter looks at the practical issues in steering the construction of the built environment towards reduced ecological footprint and greater sustainability. But the built environment is a complex thing, and with many environmental, economic and social angles to explore, we can sketch here only the key features at different scales:

- The starting point is the 'micro-scale' – the design, materials and material sources for the building fabric.
- This fits into its context at the 'macro-scale' – the location, density and form of urban areas and building types.
- There is also the question of balance between the construction agenda, and the agenda of buildings in use – whether it is better to replace older by newer buildings with improved energy efficiency.

8.8.1 Summary of results

- Construction as a whole uses 50.5 million tonnes of materials directly (DMC), and used 100 million tonnes in total material consumption (TMC). This equates to over 12 tonnes for every person in the South East region.
- The construction industry is by far the most mass-intensive of any sector: the direct material consumption is 57% of the regional total DMC from all activity and the TMC is 47% of the total from all activity.
- However the bulk of this mass is not so energy intensive: construction activity produced 23% of the total CO_2 emissions, and 17% of the total ecological footprint from all activity in the South East region.
- There are 3 million dwellings in the South East region, and approx 300,000 other buildings. New housebuilding has recently been at a rate of 22,000 per year. A much greater rate of

28,000 per year, at a 1% per year expansion of the building stock, is proposed in the regional strategy and the government's 'Sustainable Communities' programme.

Material flows in construction

- Quarry products, including aggregates, sand, crushed rock and limestone, was by far the largest type of material flow, at 43 million tonnes, or 43% of the total material consumption (TMC).
- Cement, concrete and plaster products are the next largest, at 19 million tonnes TMC.
- Slate, bitumen, stone and other non-metallic minerals are also at 18 million tonnes TMC.
- Metal and metal products of all kinds, were 8 million tonnes, and wood/wood-based products are 6 million tonnes.

Ecological footprint of construction

- There is an interesting comparison between the EF of construction of the built environment and the actual land area of the South East region, which is 1.9 million hectares. The construction footprint area ('real land' + 'energy land') is 5 times larger than the actual area of the region.
- Most of the EF is taken up with 'energy land', reflecting the high energy intensity of key construction materials (cement, bricks, glass and so on), and the small proportion of renewable materials.
- The total EF from all construction amounted to 9.5 million gha per year: the EF per person was 1.2 gha per person. This amounts to 17% of the total EF from all activity.
- The largest material EF type was 41% with minerals, bitumen and other mineral products: these are both heavy and energy intensive.
- 22% of the construction EF is taken by quarry products, where most of the energy/emissions are involved with transportation.
- 14% of the construction EF is taken by cement and plaster manufacture, which are particularly energy intensive.

Construction end uses and life cycles

- The figures shown here are for construction as a whole. If we assume that material use is evenly spread by construction spending, then there is 25% in housing, 33% in commercial, 11% in public services, 12% in industry and 19% in infrastructure (this last category is likely to use much greater proportions of bulk materials, but regional data is not available.)

Trends and projections in construction

There are many issues on different levels involved in construction, its environmental impacts, and its future trends and projections:

- Spatial strategy: the location, density and form of buildings.

- Built environment activity in the urban system: the provision of new buildings for housing, commercial and public services, and the balance of stock/turnover/demolition.
- Construction design and materials: the materials and their energy intensity required per unit of floorspace.
- Building energy and other demands over their life cycle: the length of that life cycle and their eventual fate.
- Each of the above is influenced by property market, finance, legal and professional issues, for instance where landlord/tenant split responsibility is a constraint to energy efficiency.
- Each of the above is also influenced by lifestyles and cultural shifts, for instance the move towards urban living, or away from timber frame housing.

Scenarios for the future

The many issues above suggest a scenario approach; any 'bottom up' studies on the future of construction need to combine an engineering approach with a more intangible approach:

- ***F-0- high growth scenario***: unrestricted growth in urban development, with privatisation of infrastructure, and growing use of energy and materials.
- ***F-1: business as usual scenario***: continuation of current trends, with strict controls on land use, but increasing amounts of imported materials for buildings which tend to be larger, multi-storey and higher density.
- ***F-2: low-growth scenario***: this sees a decline in the rate of construction through economic stagnation, social conflict and environmental hazards. Materials are increasingly expensive but environmental regulation is a luxury that few can afford.
- ***F-4: Factor Four scenario***: a win-win scenario based on integration of planning and development at different scales, coordination of supply and demand, accelerated technology improvements, and demand side management.

Regional policy

The regional spatial strategy has an influence on density and location, and local planning and building regulations have limited influence up to a point on building form and energy efficiency.

To go further than this, particularly for the existing building stock, would require a new raft of regional powers and resources, which might include:

- Integrated energy services consortiums which achieve step changes in energy efficiency by coordination with utilities, financiers, developers, designers, contractors, owners and tenants.
- Integrated resource management enterprises, which achieve step changes in material efficiency and material impact, by coordination between designers, contractors, material suppliers, demolition and waste managers, in the re-engineering of the built environment.

8.8.2 Overall MFA–EF results for the region

Scope and definition

As with most sectors, there is a big double counting question with construction materials: i.e. the same accounts could include limestone at the quarry, cement at the factory, concrete in the mixer, and concrete pipes delivered. The accounts below on DMC and TMC aim to correct for such double counting. Detailed analysis shows how each material type can be the ***precursor*** (raw materials), or the ***successor*** (further manufactured products), and sometimes both.

There is also a shortage of data: for minerals and aggregates there is good data on regional production, imports and exports, but for everything else there is no data available. Hence UK totals have to be apportioned by population, economic activity and industrial structure. This section also makes reference to the Construction Industry Mass Balance study (Viridis VR4).

Material flow results

There are 3 million dwellings in the South East region, and approx 300,000 other buildings. New housebuilding has recently been at a rate of 22,000 per year. A much greater rate of 28,000 per year, amounting to a 1% per year expansion of the building stock, is proposed in the regional strategy and the government's 'Sustainable Communities' programme.

- Construction as a whole uses 50.5 million tonnes of materials directly (DMC), and used 100 million tonnes in total material consumption (TMC). This equates to over 12 tonnes for every person in the South East region.
- The construction industry is by far the most mass-intensive of any sector: the direct material consumption is 57% of the regional total DMC from all activity: and the TMC is 47% of the total from all activity.
- However the bulk of this mass is not so energy intensive: construction activity produced 23% of the total CO_2 emissions, and 17% of the total ecological footprint from all activity in the South East region.

Table 8.8.1 Material flows in construction in the South East region

Primary Construction Materials (year 2000)	Consumption in the SE ['000 tonnes]	Double counting correction ['000 tonnes]	Hidden flows of materials ['000 tonnes]	Consumption + hidden flows ['000 tonnes]	TOTAL Material Flow (d.c. corrected!) ['000 tonnes]	TOTAL Material Flow per capita [t/cap]	percentage of total material flow
Quarry products	47,761	-25,678	18,530	66,252	43,204	5.32	43%
Wood products	2,498	0	0	2,498	5,749	0.71	6%
Finishes & coatings	251	0	0	251	1,861	0.23	2%
Plastic products	230	0	0	230	1,517	0.19	2%
Glass products	217	0	0	217	730	0.09	1%
Ceramic products	681	0	0	681	886	0.11	1%
Bricks & other clay products	931	0	0	931	1,214	0.15	1%
Cement plaster & concrete	20,097	-4,153	0	20,097	18,811	2.32	19%
Slate, bitumen & other minerals	6,604	0	0	6,604	17,860	2.20	18%
Metal products	1,001	0	0	1,001	8,130	1.00	8%
Cabling, wiring, lighting etc	30	0	0	30	91	0.01	0%
Overall Total	80,302	-29,831	18,530	98,793	100,053	12.33	100%

Material flows in construction

- Quarry products, including aggregates, sand, crushed rock and limestone, was by far the largest type of material flow, at 43 million tonnes, or 43% of the total material consumption (TMC).
- Cement, concrete and plaster products are the next largest, at 19 million tonnes TMC.
- Slate, bitumen, stone and other non-metallic minerals are also at 18 million tonnes TMC.
- Metal and metal products of all kinds, were 8 million tonnes, and wood/wood-based products are 6 million tonnes.

Ecological footprint of construction

Most of the EF is taken up with 'energy land' and 'transport land', reflecting the high energy intensity of key construction materials (cement, bricks, glass and so on), and the small proportion by weight (5.5%) of renewable materials.

- The total EF from all construction amounted to 9.5 million gha per year: the EF per person was 1.2 gha per person. This amounts to 17% of the total EF from all activity.
- The total footprint from all activity in the South East region is almost 7 gha ('global hectares') per person, which is 29 times larger than the actual area of _ hectare per person.

- The largest material EF type was 41% with minerals, bitumen and other mineral products: these are both heavy and energy intensive.
- 22% of the construction EF is taken by quarry products, where most of the energy/emissions are involved with transportation.
- 14% of the construction EF is taken by cement and plaster manufacture, which are particularly energy intensive.
- In terms of transport, it is clear that the EF of quarry products is 85% from transportation – hence improvements in the EF will depend on local sourcing and low impact transport modes. This has implications for the location of quarries, and also of material re-use/recycling centres in the region.
- At the other end of the scale are cement, bitumen and other mineral products, where transport is small compared to the EF of production.

Table 8.8.2 Ecological footprints in construction in the South East region

	Product CO_2 EF	Transport GWP EF	Total EF	Total EF per capita [gha/cap]	Total EF per capita [gha/cap]
Quarry products	318	1,815	2,133	0.26	22%
Wood products	390	83	473	0.06	5%
Finishes & coatings	441	5	447	0.06	5%
Plastic products	353	5	358	0.04	4%
Glass products	92	5	97	0.01	1%
Ceramic products	34	15	48	0.01	1%
Bricks & other clay products	47	20	67	0.01	1%
Cement plaster & concrete	1,079	220	1,299	0.16	14%
Bitumen slate & minerals	3,876	41	3,918	0.48	41%
Metal products	652	20	671	0.08	7%
Cabling, wiring, lighting etc	7	0	8	0.00	0%
Overall Total	7,288	2,230	9,518	1.17	100%

The construction sector shows the highest material consumption and CO_2 emissions of all economic activities and consumption sectors, and the third highest EF. A more detailed breakdown, as in Table 8.8.3, shows that aggregates (CN code 25) account for the majority of DMC and TMC, while the largest part of the EF is due to the consumption of chemical products (CN code 38). These include "Bituminous mixtures based on natural and artificial aggregate and bitumen or natural asphalt as a binder", mainly used for roofing, road surfacing and other infrastructure, which alone accounts for an EF of 3.8 million gha.

Table 8.8.3 Material CN and EF results for construction in the South East in 2000[13]

CN code	CN description	Direct Material Consumption (DMC) ('000 t)	Total Material Consumption (TMC) ('000 t)	CO_2 Emissions ('000 t)	Ecological Footprint (EF) ('000 gha)	EF per capita (gha/cap)	EF percentage of total %
25	Cement, plaster, lime, earths and stone;	53372	73985	4303	1113	0.137	12%
32	Tanning or dyeing extracts, paint etc	251	1861	1727	447	0.055	5%
38	Miscellaneous chemical products	15220	29263	22847	5911	0.728	62%
39	Plastics and articles thereof	230	1517	1383	358	0.044	4%
44	Wood and articles of wood;	2498	5749	1827	473	0.058	5%
68	Articles of stone, plaster, cement,	5871	6459	1064	275	0.034	3%
69	Ceramic products	1612	2100	446	115	0.014	1%
70	Glass and glassware	217	730	374	97	0.012	1%
73	Articles of iron or steel	978	7956	2540	657	0.081	7%
83	Miscellaneous articles of base metal	22	175	56	14	0.002	0%
85	Electrical machinery and equipment	13	39	13	3	0.0004	0%
94	Furniture & fittings nes	17	52	17	4	0.001	0%
	Totals	80302	129885	36596	9468	1.17	100%
	Double Counting Correction	-29831	-29831	-		-	
	Totals (double counting corrected)	50,471	100,053	36596	9468	1.17	

Footprint of the built environment

The built land area EF of construction in South East region adds up to 847,000 gha. This includes built-up and other urban areas but is does not include transport infrastructure (included in the transport section). On a per capita basis this adds 0.1 gha/cap to the total Ecological Footprint.

The physical land area of urban built up areas in the South East region is given as 15% of the total land area, at 288,300 hectares. This is approximately one third of the construction 'real land' EF; the remainder is due to the use of renewable materials in construction.

There is an interesting comparison between the total EF of construction of the built environment and the physical total land area of the South East region, which is 1.9 million hectares. The total construction footprint area ('real land' + 'energy land') is 5 times larger than the actual area of the region. The total EF from all activities is 29 times the physical land area of the region.

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[13] Transport CO_2 emissions and footprints are included in Freight Transport.

Table 8.8.4 Real land EF analysis of built land area in the South East in 2000

Built land area	Real Land EF	Unit
Built up areas and gardens [a)]	376	'000 gha
Other Urban Areas [a)]	471	'000 gha
Subtotal EF	847	'000 gha
Subtotal EF per capita	0.104	gha/cap

a) Does not include transport infrastructure!

Ecological construction

The obvious starting point in reducing the EF of construction is the choice of materials and sources of those materials. The chart below shows the relative total EF in extraction, production and distribution, in gha/ tonne of common building materials. Aluminium is the material of choice for many applications being light, durable and strong, but is by far the most intensive of any material.

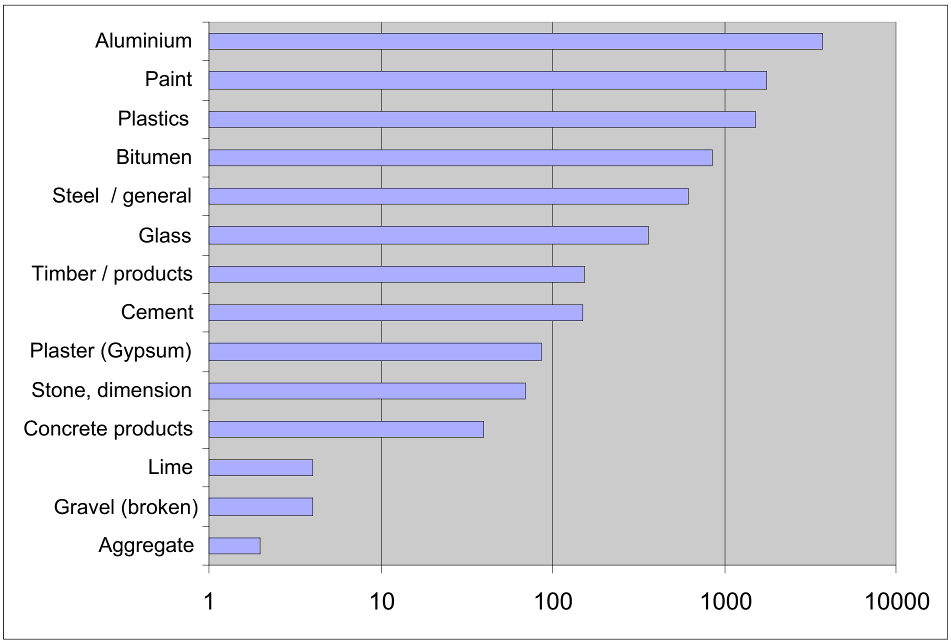

Figure 8.14 Relative total EF in extraction, production and distribution of common building materials in gha/tonne

A recent study investigated the implications of building 200,000 new homes to different environmental standards and lifestyles of residents in the Thames Gateway part of the Sustainable Communities plan for the South East.[14] By developing 200,000 new homes in the Thames Gateway to a minimum of the BRE

[14] James N, Desai P (2003) One Planet Living in the Thames Gateway, A WWF-UK One Million Sustainable Homes Campaign Report; BioRegional Development Group, June 2003

Eco-Homes 'Very Good' standard[15], many environmental savings could be made per home/year when compared with homes built to current Building Regulations:

- 32 per cent reduction in carbon dioxide (CO_2) emissions from energy use in the home, (this saving of 0.993 tonnes of CO_2/home/year equates to 198,840 tonnes of CO_2 or 54,220 tonnes of carbon for the 200,000 homes each year);
- 39 per cent reduction in water use;

The study showed that even greater savings could be made per home per year by developing all homes in the Thames Gateway to Z^2 standards (Zero fossil Energy, Zero Waste):

- 99 per cent reduction in CO_2 emissions from energy use in the home (this saving of 3.05 tonnes of CO_2/home/year, equates to 610,640 tonnes of CO_2 or 166,540 tonnes of carbon for the 200,000 homes each year).

Construction and life cycle EF

The most topical issue for the South East region is the effect of the rate of new building on the total EF, both now and into the future.

One starting point is a comparison of construction EF to total lifetime EF. This is worked out for housing (public and private), and for services (public and commercial). Industry and infrastructure are assumed to be embedded (accounted for) in other consumption sectors.

- The figures shown here are for construction as a whole. If we assume that material use is evenly spread by construction expenditure, then there is 25% in housing, 33% in commercial, 11% in public services, 12% in industry and 19% in infrastructure (this last category is likely to use much greater proportions of bulk materials, but regional data is not available.)
- This implies that 70% of construction materials are used in 'final consumption', in other words in housing or services.
- In housing, 1% of the stock is constructed new each year, with a EF in construction of 2375 gha: the other 99% of the existing stock consumes energy with a total EF in use of 4700 gha, i.e. ***twice*** the EF of construction per year. After 50 years, the EF in use equals the EF in construction.
- In services, approx 3% of the stock is constructed new each year, with an EF in construction of 4180. The other 97% of the existing stock consumes energy, with a total EF in use of 2000 gha, i.e. ***half*** the EF of construction per year. Thus the picture with regard to housing is reversed in the services sector.

The reason for this is to throw light on the key question for regional strategy – the possible effects of changing either the rate of new housing, or reducing the EF in construction, or the EF of the direct energy in use. This can be assessed over the lifetime of the building, assumed here as 80 years, but which may be shorter or longer, and depending on the national fuel and power generation mix, for which there are many

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[15] Building Research Establishment's (BRE) EcoHomes 'Very Good' standard with 'average' UK residents

possibilities. There are a number of variables here which require a composite scenario approach, as in the next section.

Table 8.8.5 Comparison of construction and life cycle EF

	proportion of total construction	EF in construction	EF energy in use / year	existing floorspace	New construction	EF in construction per new m2	EF in use per year	EF in use * 80 years per m2	Years until EF in use = EF in construction
	%	final	direct	'000 m2	'000 m2	gha	gha	gha	
Housing	25%	2375	4700	210000	2100	1.13	0.02	1.79	51
Services	44%	4180	2000	68000	1800	2.32	0.03	2.35	79
Totals	69%	6555	6700	278000	3900	3.45	0.05	4.14	

Construction and demolition life cycle

The other side of the construction coin is to look to the other end of the life cycle, at the end-fate of the materials used. At present, from the 50.5 million tonnes used in construction in the South East region each year, there are various waste streams:

- 6.4 million tonnes of mining waste from the extraction of quarry products
- 13.4 million tonnes of construction and demolition waste
- 0.3 million tonnes from the manufacture of construction products

Taking off the waste component, the result is the 'net addition' to the stock of the built environment (houses, buildings, infrastructure) in the South East region of 37 million tonnes per year (4.6 tonnes per person).

There is an agenda for the re-use and recycling of the 13.4 million tonnes of C&D waste: this arises both from construction practices on site, and from larger scale demolition of older buildings. However the EF analysis in the section above shows that the transport component is by far the largest component, implying that the benefits of re-use or recycling will depend very much on how far the material has to travel to be sorted and re-distributed.

8.8.3 Trends, scenarios and policy implications

Future trends and drivers

Generally the South East region is under more pressure than any other region, to incorporate new housing on a massive scale. There is a population growth forecast of 5.5% per decade, and a reducing household size from 2.4 to 2.1, and current problems of over-heating, congestion, housing affordability and shortages of key workers. Dealing with such problems raises interesting questions for the application of a footprint method:

- Construction of 28,000 dwellings per year will consume massive amounts of materials and energy, wherever it is done.
- However the new dwellings have the potential to be much more efficient in energy and water than the existing stock: there is technological potential to reduce resource demands almost to zero.
- Calculation of the MFA-EF depends on estimates of the life-cycle and end-fate of the new houses: this is assumed at 80 years but in practice is intended to be indefinite.
- Concentration of new construction in urban areas, will tend to generate more reclamation and demolition waste than the equivalent in a green field location.
- The planned concentration in urban areas will contribute to more sustainable transport demand patterns: however the scale of the effect may be much smaller than previously thought, and has been estimated at a 3% reduction in transport emissions.
- It is likely that the social and economic effects of regeneration, and their effects on affluence and consumer spending habits, will be much more significant certainly than the transport effects, and possibly than the direct energy requirements of the new housing.

In the light of this, there are several kinds of analysis to be carried out on current conditions, trends and projections, and their implications for policy:

- Analysis of alternative demand strategies, in terms of volume, location and type of construction.
- Analysis of alternative supply strategies, in terms of materials, design, specification and efficiency in use of construction.

Scenario settings

Built environment construction activity is closely related to population and to economic activity, although there are counter-cyclical effects from public sector construction. However the shakeout of construction/ demolition waste from the system is very sensitive to policy on regeneration, recycling, building design, use of secondary wastes etc.

Given the complex set of factors above, a very simplified set of scenario trends and drivers can be structured as follows, and tested out in the SE-MB scenario model:

- Household floorspace per head of population, for both existing and new housing (hh m^2/ pp): this equates to a simple stock and intensity model, i.e. where the growth in floorspace may be less or more than the growth in population and the growth in number of dwelling units.
- The turnover in the stock itself, as a proportion of existing stock, and the demolition of older dwellings (hh new/exg stock).
- Household energy efficiency per unit of floorspace, for new and existing dwellings (hh energy eff new/exg): this equates to a composite measure of energy demand, which is then broken down into shares of end-uses, i.e. heating, lighting etc, and shares of fuels, gas, power etc.

- Household material efficiency per floorspace (hh material eff/m^2): this applies to new construction, the volume of materials used per unit floorspace, and the EF intensity of those materials. Again this is on a highly averaged level.
- Waste arising and material life cycle (arising/re-use %): this is a compound assessment of how much bulk material stays in the system or comes out as waste, and how much of the waste then re-enters the system.
- Commercial and public services buildings need a similar range of units as for housing above. The difference is that they are not related to population in the same way, rather to economic growth, the structure of the economy (commercial/public/industry), and the intensity of floorspace per unit of economic activity.

Table 8.8.6 Scenario settings for construction (housing and services)

CONSTRUCTION			SCENARIO DRIVERS						MAIN SUB-TYPES		
	Stock factors	consump-tion	producti on factors	technol ogy factors	activity / stock	waste factors					
		hh m^2/pp	hh material use & EF/ m2	hh energy eff new / exg	hh new/ex g stock	re-use %	Housing	Commer cial	Public	Industry	Infrastru cture
F-0 High growth		Rapid growth	Growth	Rapid growth	Rapid growth	Reduc-tion	Rapid growth	Rapid growth	Reduc-tion	Growth	Growth
F-1 Business as usual		Growth	Stable	Growth	Growth	Stable	Growth	Growth	Stable	Stable	Rapid growth
F-2 low growth		Stable	Stable	Stable	Stable	Reduc-tion	Reduc-tion	Reduc-tion	reduction	Stable	Reduc-tion
F-4 Factor Four		Reduction	Reduc-tion	Reduc-tion	Reduc-tion	Rising	Stable	Stable	Rising	Reduc-tion	Growth

Future scenarios

The scenario approach is well established in transport studies, which combines the engineering approach with a more volatile 'lifestyle' approach.

F-0 – high growth: Housing shows polarisation of growth and decline based on access to hubs and services, so that prices in desirable areas are sky-high, and in others falling below zero. More households find themselves 'hot-housing' between a number of dwellings in different locations and tenures, which suits the new pattern of extended kinship networks coming from multiple marriages, children and other dependents. For commercial property, there is rapid turnover with increased fluidity and restructuring in skills, occupations, tele-work and job migration. Many people are now distributed and networked in both housing and workplace, on a continuous round of short or long term commuting and migration. Dwelling sizes and disposable incomes increase steadily while household sizes reduce, so the average space per person doubles over 50 years.

F-1: business as usual: Building construction is transformed from its current rather adhoc style to a sophisticated operation of integrated planning, which matches producers, consumers, locations and total values to society and the economy. For ***housing,*** there is strategic management of the balance of housing demand and supply, with sophisticated market intervention to ensure balanced provision of tenures, prices, types and fitness. The effects of such technocratic social engineering shows most strongly in housing, where some of the forms are in danger of over control, and there is tension between the surveillance for security and civil liberties. There is a general re-urbanisation of housing which then relies on more complex multi-storey designs and management.

F-2: low growth: In towns and cities there is a managed retreat to major urban hubs which offer the best in controlled climate, sealed environments and continuous security, but among these there are steep price differentials. ***Housing activity*** is driven by many areas which see increasing household size, due to the need for indoor comfort, containment and security. To enable this new housing forms and tenures are evolved, with many ending up in condominium-style blocks in the cities, and self-contained private villages in the countryside. There are large inter-regional displacements of housing and jobs due to climate stress, and large flows outwards to rural new communities. Inward migration to the city centres is seen as highly desirable and available only for the wealthy, so the majority are channelled towards mixed developments of flats over shopping centres with sealed environments and continuous security.

F-4: Factor Four scenario:

This 'win-win' scenario sees the quality and general efficiency of in the production of the built environment increase rapidly:

The renaissance of city living allows large-scale redevelopment of brown field sites, particularly around the estuary and former industrial/military sites. Affordable housing is managed through community owned housing associations and co-ops, exploiting the availability of old office space as the demand for this reduces. The greater proportion of older people in society and generally increased life expectancies reinforce the collective social conscience and lead to a reintegration of community centres; schools, daycare centres and nursing homes are located together. There is a strong move towards community living, extended families sharing houses, etc. There is some redistribution around towns and cities, but also a kind of 'drawbridge' effect – to maintain community spirit, many neighbourhoods become more mono-cultural and inward looking. Urbanisation of the country slows and there is a net balance of counter- and re-urbanisation between countryside and urban areas. The shape of the region shows rapid changes as many former differences are reversed, where inner city communities become desirable, and where expensive suburbs decline and restructure.

In housing, majority lifestyles now favour the quality of space and proximity over the quantity of space, as for once people seem to what to live together. There are new housing forms and tenures to reflect new patterns of organisation, where groups and networks of families cooperate on childcare, schooling and transport. Older terraces and even suburban estates are converted for such networks, but social differences often turn such arrangements into defensive territory with high physical security and inward orientation.

In property, the distribution of space for work and public services shows rapid changes, as specialised functions in warehouses and offices are replaced by generalised mixed functions organised at the local level. Offices are converted to housing in city centres, and vice versa in the suburbs, while increased manufacturing space is distributed to meet the needs of a localised economy.

Implications for regional strategy

Generally the South East region is under more pressure than any other region, to incorporate new housing on a massive scale. There is a population growth forecast of 5.5% per decade, and a reducing household size from 2.4 to 2.1, and current problems of over-heating, affordability and shortages of key workers. Dealing with such problems raises interesting questions for the application of a footprint method:

- Construction of 28.000 dwellings per year will consume massive amounts of materials and energy, wherever it is done.
- However the new dwellings have the potential to be much more efficient in energy and water than the existing stock: there is technological potential to reduce resource demands almost to zero.
- Calculation of the MFA-EF depends on estimates of the life-cycle and end-fate of the new houses: this is assumed at 80 years but in practice is intended to be indefinite.
- Concentration of new construction in urban areas, will tend to generate more reclamation and demolition waste than the equivalent in a green field location.
- The planned concentration in urban areas will contribute to more sustainable transport demand patterns: however the scale of the effect may be much smaller than previously thought, and has been estimated at a 3% reduction in transport emissions.
- It is likely that the social and economic effects of regeneration, and their effects on affluence and consumer spending habits, will be much more significant certainly than the transport effects, and possibly than the direct energy requirements.

The current regional ***mineral strategy*** contains two key targets for maintaining landbank resources for the largest materials types of aggregates, sand and gravel.

- Production of aggregates: 13 million tonnes per year.
- Production of crushed rock: 2.2. million tonnes per year.
- The use of secondary aggregates and recycled materials should increase from 5.3mtpa (23%) to at least 7.4mtpa (33%) by 2016, to reduce the need for primary aggregates extraction.

The current consumption of minerals and aggregates, including crushed rock, sand and gravel is approximately 22 million tonnes (after correcting for double counting). Therefore the South East region is about 2/3 self-sufficient. Proportional to its population density it produces more than its share of minerals and aggregates.

Role of construction in the Factor 4 scenario

The implication is for some level of tradeoff between the construction sector, where F-4 levels of reductions are difficult to anticipate, and the building direct energy sector, where large reductions are technically feasible. In summary this preferred, desirable or 'sustainable' Factor Four scenario involves a range of principle for integrated resource management:

- Increased eco-efficiency and reduced materials intensity per unit of floorspace
- Reduced primary inputs, and increased recycling and secondary use
- Zero-waste construction and demolition practices
- Integrated materials management systems
- Economic and institutional systems to promote integrated materials management

These principles will apply to many changes and many professions in practice:

- Building lifecycles and urbanisation – planning agenda
- Environment and planning policy for extraction and waste
- Forcing up the price of raw material
- Materials ownership and shared leasehold
- Materials logistics and distribution systems
- Minerals and waste taxation: integrated system
- Transport policy and taxation: sticks and carrots
- Materials specifications/performance specifications
- Recycling and secondary use – link to economic development

It is also important to be aware of the tensions and conflicts in the factor four approach, including the key issues below:

- building durability vs recyclability
- resource reduction vs jobs in the industry
- lean design vs building flexibility
- lean design vs secondary aggregates
- integrated consortiums vs out-sourcing
- guaranteed material markets vs dangers of intervention
- integrated material management vs transport costs
- material substitution vs transport costs

The construction industry in the UK is generally known for being conservative, inefficient and materials intensive. Again achieving a Factor Four scenario will depend on a totally integrated approach:

- Designers and specifiers
- Smart geotechnics, concrete and masonry

- Construction management in the industry
- Labour skilling and tooling
- Alternative construction methods
- Alternative materials specifications
- Performance based specification: risk factors
- From demolition to demounting
- From waste management to resource management

8.9 Waste

Solid waste is the residue at the end of the material chains of an industrial society – a massive resource devalued to zero or less, by total 'entropy' or disorder. Until recently the waste industry was mainly concerned with holes in the ground, but now there is no such thing as a cheap and environmentally friendly method of disposal. In the longer term, the issue is not so much ***waste*** management as ***materials*** management – where recycling, re-using and minimisation are the only viable options. This involves re-organising and re-engineering material chains and processes throughout the region.

In reality this is a huge challenge. The growth in national waste arisings of 1–3% per year (in the absence of better information) could double in 25 years, and responsibility for such a growing mountain is fragmented into many competing purchasers and providers. At each stage in the material chain there are government, counties and districts, partnership companies and private companies. Each is getting to grips with interlocking contracts, new subsidies and taxes, new technology, new environmental standards, new targets and Directives, and new commodity markets – altogether a rich mixture.

The main contribution of the regional MFA-EF study is to provide some fundamental information on the environmental impacts and benefits of waste streams and different options for management. This is at least a start in piecing together the bigger picture of the Factor Four strategy for the region as a whole.

8.9.1 Summary of results

Material flow results

A total of 36.8 million tonnes of waste were produced in the South East region in 2000. Over one third of this was in construction and demolition (C&D) waste – nearly all of which is inert waste (non-biodegradeable).

The waste management industry dealt with 25 million tonnes of this waste: including 4.2 mt of municipal solid waste (MSW), 7.2 mt commercial and industrial (C&I), and 13.5 mt of construction and demolition waste (C&D). Special and hazardous wastes, such as car tyres and hospital wastes, amount to 500,000 thousand tonnes.

- The 6 million tonnes of quarry and mining waste is generally managed on site, as is the 6 million tonnes of agricultural waste.
- The 4.2 million tonnes of 'municipal' waste (i.e. collected by local authorities) is only 11% of the total, but the most difficult and expensive to deal with, as it is a mixture of material types, spread around in many locations.
- Commercial waste was around 5.8 million tones, almost 16% of the regional total, with industrial waste (excluding all construction waste) of approximately 1.4 million tonnes. Each of these have much higher rates of recycling and recovery, as they have generally larger volumes of recycleable materials.
- Commercial waste is notable as nearly half of it is in paper and card products; around 30% of the total is recycled at present.

- Sewage sludge amounted to 151,000 tonnes per year: this is small in relation to total waste flows, but a sizeable problem.
- The South East also took 3.2 million tonnes of waste from Greater London, much of this in C&D waste, and this volume is projected to be halved in 20 years.

Ecological footprint results

The EF method is detailed in the next section, and should be seen as a 'satellite account', i.e. not to be added to the EF of the main consumption sectors for the region as a whole.

- The EF for municipal solid waste management in the South East region amounts to 4.5 million gha/yr: this equates to 8% of the overall regional total EF.
- From the Municipal Solid Waste stream (MSW), paper and card carries over 50% of the total EF from MSW landfill. Other combustibles account for 16%.
- For construction and demolition waste (C&D), some notional EF can be derived in terms of the tonnage of bulk material taken to landfill, which amounts to 13.4 million tonnes (this excludes hazardous and contaminated waste).
- Other waste streams including agricultural and quarry wastes are accounted for separately in the EF factors for production in the relevant sectors.

Regional strategy analysis

The regional waste strategy was analysed in terms of each material stream, and for the overall EF. (Chapter 4). The results show that a 58% reduction in EF from the waste sector is possible by 2020. This assumes the 'central' growth scenario of the regional strategy, which forecasts a 60% growth in waste arisings by 2020.

The benefits in EF depend on moving rapidly towards the technical optimum for recycling of each material type, with 70–80% for metal, glass and paper, and 55% for the waste stream as a whole. This also assumes that recycled materials are put to 'high-level' uses, i.e. substituting for the original material, rather than being used as bulk fill. It also assumes, bravely, that recyclables markets are working perfectly, i.e. that there are no mountains, dumps or pinch points. (This has not been confirmed by recent experience in recyclables markets.)

Policy context

The South East Regional Waste Strategy (consultation draft 2003) is based on the 'central' growth scenario for waste arisings, a 60% rise by 2020. To achieve the reduction in landfill disposal required by the EC Directive and UK guidance, the Strategy proposes rapid increases in recycling, and a diversity of treatment technologies, with more benefits coming from larger facilities.

However in the sustainability appraisal, the question of waste minimisation was left outside the study boundary. Arguably this question is crucial to considering the waste strategy as part of a larger regional strategy for 'integrated resource management'.

Future trends and drivers

Waste arisings are difficult to project and to model: there is great uncertainty on the current growth rate of waste arisings, and future trends need a scenario approach with a range of factors.

The basic drivers are population, which is relatively predictable, and economic growth and/or disposable income, which is less so. Hence the estimation of the strategy's 'central' scenario as based on 'population growth + 2% tapering off to 0.5%', represents a combination of aspiration and anticipation, rather than anything more scientific. Behind this lies a great diversity of influences:

- Product composition and structure: materials and compounds, particularly those which are chemically hazardous or physically difficult to separate.
- Packaging volumes and designs, which is a result of supply chain logistics and distribution as much as technology.
- Design for re-use, re-engineering, disassembly or other means of recycling or recovery.
- Cost of raw materials vs recycleate markets: and the degree of intervention in such markets.
- Infrastructure for distribution collection and re-distribution, and 'participation rates' among householders and businesses.
- Infrastructure and new technology for waste management.

Implications for regional policy

The regional waste strategy has set out its stall, with the implication that only an ambitious shift towards a low-impact waste system can deliver the targets with the maximum of benefits. The consultation question is basically on the appropriate balance of aspiration (exceeding the targets) with practicality (meeting the targets). However there are risks in relying partly on new methods with unproven technologies and commercial viabilities. There is also a risk that the environmental and EF targets will be missed, because the question of where the waste comes from, and how far the stream can be minimised, is mainly outside the powers or resources of the public sector.

In this larger frame, success could only be achieved by coordination of public waste management for MSW, with private sector waste management of C&I and C&D and special waste streams. It also depends on coordination between retailers, packagers, producers, and many others. Possibly the most effective way forward is through an accelerated 'greening' of public sector purchasing and procurement, within a regional strategy for 'integrated resource management'.

8.9.2 Overall MFA–EF results for the region

Scope and definition of waste management

The waste management accounts are in the form of a 'satellite' account to the main division of consumption sectors as in Section 8.1. This is because the materials which go to waste are already counted in the EF of production and transportation of materials which are consumed. For instance in the food sector, while 14% of domestic food ends up in the bin, around 43% of commercial catering is wasted: this is included in the food account and explains the higher EF factors for commercial catering.

However the waste management accounts are more important to regional strategy than their size would suggest. As the sector where its basic materials have zero or negative value, the waste sector is the key to integrated resource management – working back up the supply chain, to improve the efficiency and lower the impacts, of production, distribution and utilisation of materials of all kinds.

The assessment and modelling of the ecological footprint of waste can be divided into six categories, (with details in Chapter 4):

- The ecological footprint of waste to landfill: based on the EF of production of all the material disposed.
- The ecological footprint of recycled and composted waste: including the EF of re-processing, minus the EF of the material which is retained.
- The ecological footprint of organic waste to landfill: including the direct EF from methane and other GHG emissions.
- The ecological footprint of waste transportation: estimates of haulage and its EF for all types of waste disposal.
- The ecological footprint of the energy requirements of landfill processing: on site movements and landfill engineering.
- The ecological footprint of incineration: based on the EF of production of all the material disposed, plus the EF of emissions, but minus the offset EF of the energy produced.

Material flow results

A total of 36.8 million tonnes of waste were produced in the South East region in 2000. Over one third of this was in construction and demolition (C&D) waste – nearly all of which is inert waste (non-biodegradeable).

The waste management industry dealt with 25 million tonnes of this waste: including 4.2 mt of municipal solid waste (MSW), 7.2 mt commercial and industrial (C&I), and 13.5 mt of construction and demolition waste (C&D).

- The 6 million tonnes of quarry and mining waste is generally managed on site, as is the 6 million tonnes of agricultural waste: i.e. these do not enter the official waste management system.
- The 4.2 million tonnes of municipal waste (collected by local authorities) is only 11% of the total, but the most difficult and expensive to deal with, as it is mixed materials and coming from many locations.
- Commercial waste was around 5.8 million tones, almost 16% of the regional total, with industrial waste (excluding all construction waste) of approximately 1.4 million tonnes. Each of these have much higher rates of recycling and recovery as they have generally larger volumes of recycleable materials.
- Commercial waste is notable as nearly half of it is in paper and card products. Around 30% of this is recycled at present.

- Sewage sludge amounted to 151,000 tonnes per year: this is small in relation to total waste flows, but a sizeable problem.

The relative proportions of these streams are shown in the table and the chart below:

Table 8.9.1 Total regional waste proportions and 'business as usual' projections.

	waste arising 2000	proportion of total 2000	BAU projection 2005	BAU projection 2010	BAU projection 2015	growth 2000–15	growth rate per year
Industrial	4511.8	12%	4820.4	5253.8	5686	26%	1.6%
Commercial	4638.3	12%	5395.6	6089.8	6889.5	49%	2.7%
Municipal - Household	4157.3	11%	4890.1	5717.8	6692.3	61%	3.2%
Municipal - Other Waste	186.6	0%	229.2	262.4	302.7	62%	3.3%
Construction & Demolition	13359.9	35%	15683	17014.6	18734.7	40%	2.3%
Agricultural	4918.9	13%	4432.1	4532.3	4615.4	-6%	-0.4%
Mining	6428.8	17%	6466.5	6610.6	6946.8	8%	0.5%
Sewage Sludge	151.7	0%	156.9	161.4	166.2	10%	0.6%
Power Station Ash	86.7	0%	91.7	94.9	98.3	13%	0.8%
Total	38440	100%	42165.5	45737.7	50132	30%	1.8%

Source REWARD modeling system (www.reward-uk.org)

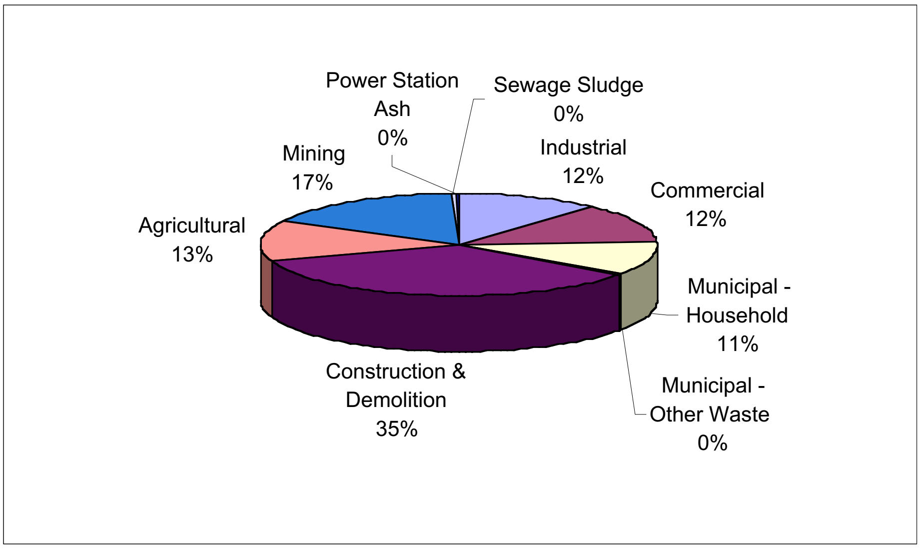

Figure 8.15 Proportions of the total waste stream in the South East region

(NB The table and chart are based on Environment Agency waste estimates which differ in some cases from the Taking Stock research on waste data, particularly in the case of commercial and industrial waste. They are included for illustrative purposes. See Chapter 4 for further details.)

Ecological footprint results

The EF method should be seen as a 'satellite account', i.e. providing essential detail, but not to be added to the aggregated EF of the main consumption sectors for the region as a whole.

- The EF for municipal solid waste management in the South East region amounts to 4.5 million gha/yr: this equates to 8% of the overall regional total EF.
- From the Municipal Solid Waste stream (MSW), paper and card carries over 51% of the total EF from MSW landfill. Other combustibles account for 16%.
- For construction and demolition waste (C&D), some notional EF can be derived in terms of the tonnage of bulk material taken to landfill, which amounts to 13.4 million tonnes (this excludes hazardous and contaminated waste).
- Other waste streams including agricultural and quarry wastes are accounted for separately in the EF factors for production in the relevant sectors.

Comparison with regional metabolism

The total waste arising of 36.8 million tonnes amounts to is nearly half of the Direct Material Consumption (DMC) of all activity in the South East region, at 88 million tonnes. However a more accurate picture would exclude the wastes from regional ***production*** in agriculture, mining and construction, and focuses on the wastes of ***consumption,*** i.e. MSW and commercial: in this case the waste arising of around 10 million tonnes is apparently only 11% of all direct material consumption (DMC) in the region. This suggests that the other 89% either is emitted to air or water, or in other forms of non-managed waste, or it stays in the system. The accumulation of material in the built environment is detailed in the previous section, i.e. the 'net addition' to the stock of the built environment (houses, buildings, infrastructure) in the South East region of 37 million tonnes per year (4.6 tonnes per person).

County level analysis

Three of the sub-regions have a significantly higher recycling rate than others (Hampshire and West Sussex and Buckinghamshire and Milton Keynes). There is a considerable difference between the recycling rates of the sub-regions, the lowest being Kent and East Sussex (14 per cent) and the highest Hampshire (23 per cent). Hampshire is the only sub-region that has nearly achieved the government target of a 25 per cent recycling by 2005. All the sub-regions of the South East have achieved a higher recycling rate than the UK average. In terms of the tonnage of waste produced per capita, sub-regions that have higher recycling rates also, on average, produce more rubbish.

This analysis indicates the ability of the sub-region to maximise efficiency within the waste stream. In essence, "EF per tonne" provides a valuable indicator of resource productivity. Berkshire is able to process their waste more efficiently than any of the other sub-regions. Potential reasons for this include lower embodied energy in the waste stream due to a different material composition or the different recycling composition.

Policy context

The regional strategy was analysed in some detail, for the implications for each material stream and for the overall EF (Chapter 4). The results show that a 58% reduction in EF from the waste sector is possible by 2020. This assumes the 'central' growth scenario of the regional strategy, which forecasts a 60% growth in waste arisings by 2020.

The benefits in EF depend on moving rapidly towards the technical optimum for recycling of each material type, with 70–80% for metal, glass and paper, and 55% for the waste stream as a whole. This also assumes that recycled materials are put to 'high-level' uses, i.e. substituting for the original material, rather than being used as bulk fill. It also assumes, bravely, that recyclables markets are working perfectly, i.e. that there are no mountains, dumps or pinch points. (This has not been confirmed by recent experience in recyclables markets).

The regional waste strategy (consultation draft 2003) is based on 'central' growth scenario for waste arisings, of 60% rise by 2020. To achieve the reduction in landfill disposal required by the EC Directive and UK guidance, the Strategy suggests rapid increases in recycling and a diversity of treatment technologies, with more benefits coming from larger facilities.

However in the sustainability appraisal, the question of waste minimisation was left outside the study boundary: this question is crucial to considering the waste strategy as part of a larger regional strategy for 'integrated resource management'.

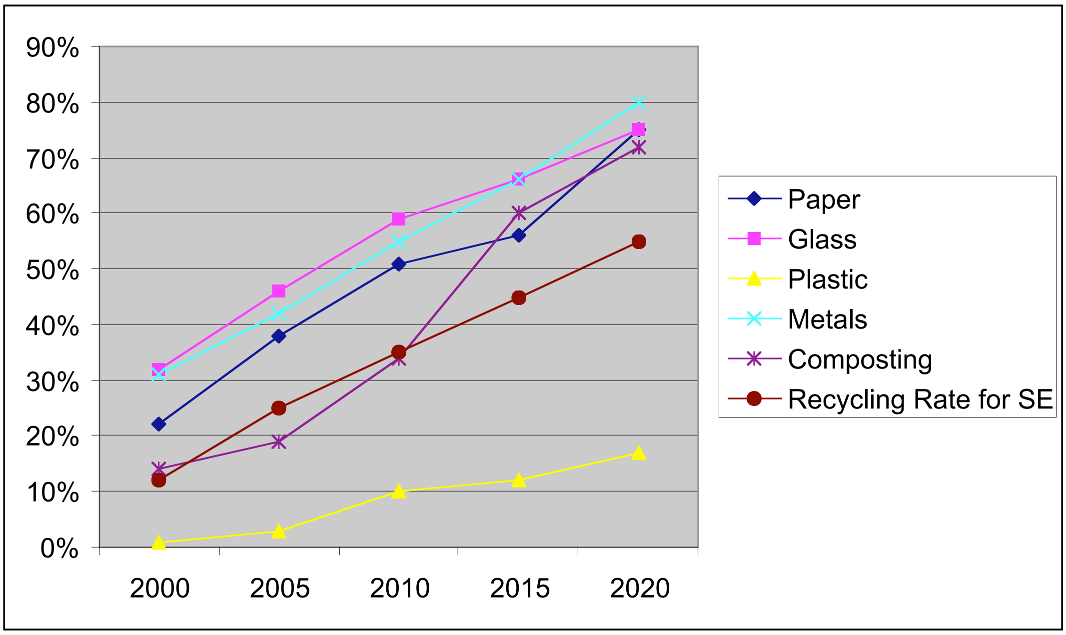

Figure 8.16 Material recycling rates in the 'best practice' scenario: as from Chapter 4

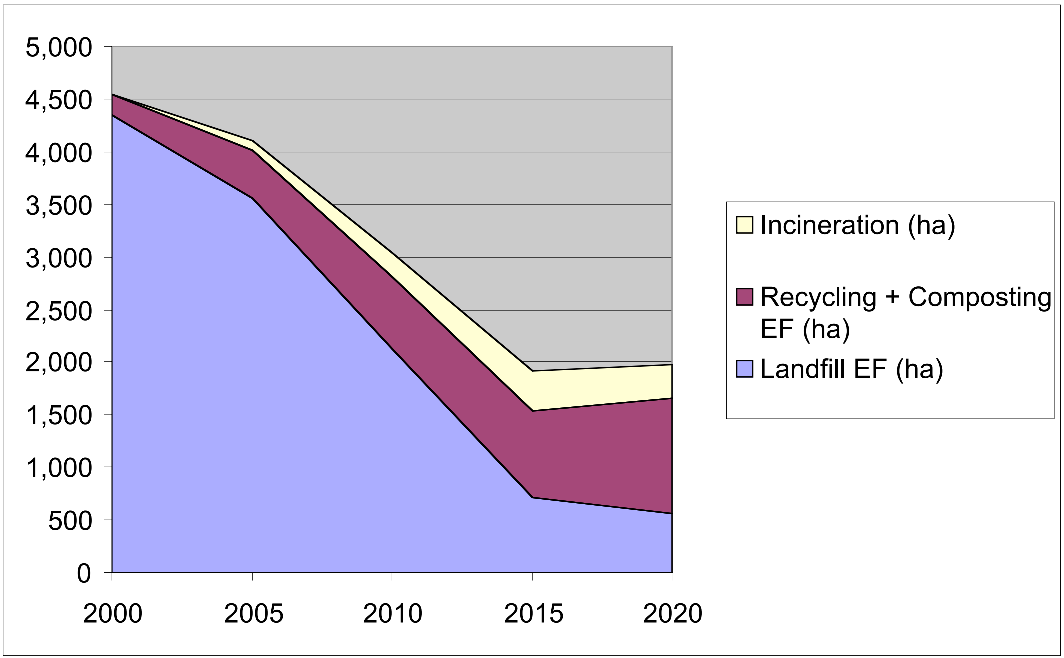

Figure 8.17 Aggregated Ecological Footprint of waste management in the 'best practice' scenario: as from Chapter 4. (units in 1000s of gha/yr)

8.9.3 Trends, scenarios and implications

Future trends and policy options

The general uncertainty in waste management trends and forecasts is surprisingly high. The 'best case' recommendation in the regional strategy, analysed in detail in Chapter 4, is one example of thinking through the implications at the regional scale. However there is a a need to look beyond the 25 year time horizon of the regional strategy, and beyond the various options which are identified in detail. To do this might draw from work such as the World Resources Institute, and the Greater London waste study, which shows how many cities and regions around the world have a quite different approach to waste, recycling and re-manufacturing.[16]

Municipal Solid Waste (MSW): Four scenarios for waste arisings were developed for examination. A central, or best estimate, scenario is used for the sustainability assessment of scenarios, with three other profiles considered in a sensitivity analysis of the capacity of infrastructure needed to meet targets under the alternative scenarios.

- ***Base case***: as assumed by the EC Directive and UK Waste 2000: 3% annual growth throughout: net change 2000/2025 amounts to +103%.
- ***Central scenario***: starting at actual household growth plus 2% (2.9784%), tapering off to household growth +0.5% (1.2834%): net change to 2025 amounts to +59%;

[16] Murray R et al (1999) Re-inventing Waste: towards a London Waste Strategy, London, Ekologica

- ***Household growth***, i.e. related to population size with no other changes: current annual growth of 0.9762%, tapering to 0.7834%: net change 2000/2025 amounts to +23%.
- ***Rapid minimisation***: initially 3% annual growth, tapering to –3% annual reduction, giving a –14% net change (reduction).

Commercial and industrial (C&I) waste forecasts: Two scenarios are considered jointly, starting from a current high rate of growth at 3.27%.

- Declining growth: initially 3.27% growth, tapering to 1% growth: net change 2000/2025 amounts to +64%
- Rapid minimisation: initially 3.3% growth, tapering to –3% growth: net change 2000/2025 amounts to +4%

Waste arisings are notoriously difficult to project and to model: there is great uncertainty on the current growth rate of waste arisings, and future trends need a scenario approach with a wide range of factors.

The basic drivers are population, which is relatively predictable, and economic growth and/or disposable income, which is less so. Hence the estimation of the strategy's 'central' scenario as based on 'population growth + 2% tapering off to 0.5%', represents a combination of aspiration and anticipation, rather than anything more scientific. Behind this lies a great diversity of influences:

- Product composition and structure: materials and compounds, particularly those which are chemically hazardous or physically difficult to separate.
- Packaging volumes and designs, which is a result of supply chain logistics and distribution as much as technology.
- Design for re-use, re-engineering, disassembly or other means of recycling or recovery.
- Cost of raw materials vs recycleate markets: and the degree of intervention in such markets.
- Infrastructure for distribution collection and re-distribution, and 'participation rates' among householders and businesses.
- Infrastructure and new technology for waste management.

Future scenarios

The waste sector is a good example of scenario studies, where alternative forecasts are used an essential part of the strategic planning process. This applies to both the demand side (waste arisings) and the supply side (waste facilities and technology), and it is perhaps a reflection of the degree of uncertainty involved in managing the waste sector. The issue here is how the above 'bottom-up' regional strategy options and scenarios may link and coordinate with the 'top down' footprint scenarios used for other sectors, in particular the Factor Four scenario and its implications.

- ***F-0 high growth***: this scenario corresponds to the continuing 3% annual growth in waste arisings. More generally it is a result of the accelerating trend in the 'throwaway society', where increasing amounts of material are processed, purchased and disposed, in ever shorter time cycles. There are localised problems in the handling of this waste, but various kinds of mechanical and biological treatment (MBT) technology continues to develop for processing and recovery, which basically compresses larger tonnages of waste into smaller volumes. However the MBT technology is increasingly energy intensive to deal with more special and hazardous waste streams, and the result is that the total EF in the waste sector also doubles in 25 years.

- ***F-1: business as usual***: this scenario corresponds to an interesting combination of aspiration and reality on the part of the South East Regional Waste Strategy. The 'central' scenario for MSW and C&I waste streams sees net annual growth at 1.9–2.0%, while imports from London taper off. The Strategy scenarios for waste management see a diverse mixture of larger scale technologies, with a rather brave assumption that recycling rates multiply several times up to 50–75%. This corresponds in some ways with the F-1 ethos, which sees enlightened public management as containing the worst impacts of free market behaviour without restricting the root causes. The EF in this scenario would be roughly static, a balance between growing volumes and increasing recycling rates.
- ***F-2: low growth***: This scenario is a topical alternative to the apparently smooth trends and forecasts, by assuming that whatever can go wrong probably will. Consumers refuse to participate, new facilities cannot get planning permission, the MBT technologies don't work as expected, and there is massive shakeout of commercial operators. The result in this scenario is complete chaos, where temporary waste mountains occupy derelict land in urban areas, and where attempts at supply chain management and packaging re-use are too complex to be workable. The implications for the EF would be for zero growth in waste arisings, while processing and recycling fail to take off, and hence stalemate all round.

F-4: Factor Four scenario

The Factor Four scenario is closely aligned with the 'rapid minimisation' forecast of the Strategy, i.e, initially 3% annual growth, tapering to –3% annual reduction, giving a –14% net change (reduction) in waste arisings. This can be coupled with recycling rates which are better than planned, and up to the technical optimum for each material stream.

Naturally this scenario depends on social, political and cultural changes which then produce the desired framework for integrated resource management. In particular it highlights the positive combination of trends, which the regional waste strategy might be able to influence if not to control:

- Consumers have a growing awareness of the material basis of their existence: this may be accelerated with new ICTs which link interests of developed and developing countries, in a rapid expansion of fair and ethical trading schemes.
- Producers and suppliers shift the supply chain patterns, design specifications etc. to favour less waste intensive products.
- Fiscal systems such as the landfill levy are strengthened and widened, providing strong signals which increase re-use and recycling up to the technical optimum.
- International trading rules are shifted to equalise environmental and employment regulation between developed and developing countries: this drives up material prices and increases incentives for re-use and recycling.

- Public sector purchasing and procurement is based on aggressive policies for improved social and environmental criteria in all products and services: this helps to gain critical mass in the main materials markets which are then managed by partnership consortiums.

The overall result and EF forecast for this scenario would in principle see a halving of waste volumes, with a doubling of efficiency in recovery or recycling.

Contribution of waste management in the F-4 context

Overall the prospects for waste management in the South East region show pressing problems and uncertainties – but on the horizon, a new kind of material metabolism in production and consumption. Non-essential throughput would be minimised, all products would be designed for re-use and recycling, and remaining waste would be sorted on collection. Organic and nutrient-rich materials from households, agriculture, and industry would be linked through local and regional eco-cycles.

The analysis undertaken of the different waste streams supports the theories behind the "Waste Hierarchy". In every case it is beneficial not to produce the waste in the first place. This was demonstrated both in the scenario and the analysis of the counties.

- The 58 per cent reduction in the ecological footprint demonstrated in the scenarios would be a considerable achievement for the South East. This represents an average yearly reduction of 2.9 per cent.
- A high forecast for waste growth by 2020 suggests a 60 per cent increase in waste by 2020, while the scenario suggests that this can be limited to 19 per cent.
- Without limiting the growth in waste the ecological footprint of domestic waste in the South East would have reduced by 29 per cent, not 58 per cent. Therefore, it is possible to include that the waste minimisation component of the scenario was responsible for approximately half of the total reduction.
- To achieve the reduction in the growth of waste serious thought is required about how this is going to be achieved. On of the suggestions listed in the PIU Report is to introduce a "Pay by Weight" scheme. This would involve the cost of waste disposal being shown separately from the Council bill and the weight of a household's waste would determine the amount of they would pay for waste disposal.

Within the county analysis the ecological footprint could be seen as an indicator that offers comparison of overall performance of the waste stream and as a measure of resource productivity. One of the interesting conclusions to draw from the analysis is that the sub-regions with the highest recycling rates did not necessarily have the lowest ecological footprint. The reasons for this being that the sub-regions in question produce a considerably larger volume of waste. Again, the importance of waste minimisation materialises as the most effective method by which to reduce the impact of the waste stream.

The analysis highlights particular materials of concern that cannot be recycled or where the benefits of recycling are marginal. To achieve a waste stream that nearly consists of only recyclable materials would be a key indicator for 2020. This would make the recycling targets for 2020 easier to achieve.

As previously mentioned that South East is also considering a range of other waste disposal options such as mechanical biological treatment and gasification. Further work is required to understand the feasibility of such approach and their potential impact.

Finally, once the waste system has achieved maximum efficiency (i.e. maximum recycling and composting rates), if the volume of waste continues to increase then the ecological footprint will increase, albeit at a lower rate than before. Therefore, in the short term more sustainable waste technologies can only act as a method to compensate for the growth in waste.

Policy implications

The regional waste strategy has set out its stall, with the implication that only an ambitious shift towards a low-impact waste system can deliver the targets with the maximum of benefits. The consultation question is basically on the appropriate balance of aspiration (exceeding the targets) with practicality (meeting the targets). However there is a risk of failure, because it relies partly on new methods with unproven technologies and commercial viabilities. There is also a risk that the environmental and EF targets will be missed, but also because the question of where the waste comes from, and how far the stream can be minimised, is mainly outside the powers or resources of the public sector.

In this larger frame, success could only be achieved by coordination of public waste management for MSW, with private sector waste management of C&I and C&D and special waste streams. It also depends on coordination between retailers, packagers, producers, and many others. Possibly the most effective way forward is through an accelerated 'greening' of public sector purchasing and procurement, within a regional strategy for 'integrated resource management'.

8.10 Conclusions: Achieving Factor Four

8.10.1 Why reduce ecological footprint?

This section is a final overview of the results of the Material Flow Analysis/Ecological Footprint (MFA-EF) study on the South East region. In particular it focuses on the question – how to achieve the Factor Four (F-4) reductions in EF which are called for.

This is all the more topical, now that the F-4 concept is not only the idealistic dream of environmentalists: it is enshrined in the UK Energy White Paper, which sets out the long term scientific target for climate change emissions, of 60% reduction by 2050. While there is a difference between accounting for CO_2 and EF, they are very closely related. The Taking Stock project aims towards this 60% target, but on a global scale, this takes account of disparities in wealth and in emissions between developed and developing nations, on the principle that the rich who are mainly responsible for the problem should be mainly responsible for solving it. This is the basic logic for the overall target of Factor Four, or 75% reduction by 2050.

This might be very laudable, but in practical terms it is very clear that there is no 'straight line' in policy terms, and that achieving such targets will be a matter of linking between complex social economic and political goals. So the brief overview here focuses on four main themes:

- Taking Stock of the metabolism of the South East region: an overview of the main results of the research.
- Targets and scenarios for ecological footprint in each sector: bringing together and balancing between opportunities and barriers in different sectors.
- Opportunities for integrated resource management, with a range of models and examples.
- Implications for the region, given the current limitations of regional level governance.

8.10.2 Taking Stock: the metabolism of the South East region

The Taking Stock project set out to analyse the material metabolism of the residents of the South East region of England, and to investigate ways to reduce its global impacts.

- The context is the UK Government's target of ***60% reductions*** in climate emissions by 2050, as in the Energy White Paper. This is the scientific advice for reductions necessary between all nations.
- The Taking Stock project recognises the inequalities between rich and poor nations, and their different contributions to climate change and other impacts. So for the South East region, one of the richest in the world, it sets out a target of ***'Factor Four'***: a ***75% reduction*** in the Ecological Footprint.
- To support this target the project has analysed the entire physical throughput of materials and energy in the South East region, using best available data.

- It has also reviewed current policies and strategies in the region: and then reviewed alternative development paths and scenarios for the next 25–50 years.
- The analysis is mainly based on 'consumption' rather than production within the region. As many industries and supply chains are increasingly global in scale, this is a more comprehensive kind of analysis.
- The results focus on three main physical indicators: direct and/or indirect material consumption; CO_2 as the main climate change emission; and ecological footprint, measured in 'global hectares per year'.

Material flow analysis

The first set of findings focuses on the material flow analysis, and the concept of 'mass balance':

- The direct material consumption (DMC) for the South East region is 88 million tonnes per year. This equates to ***11 tonnes per person***.
- The total material consumption (TMC) (including indirect material flows of imports and domestic production) is 211 million tonnes per year. This equates to ***26 tonnes per person***. The total input is 2_ times the direct material input to the regional economy.
- The direct outflow of materials in solid waste form amounts to 36.8 million tonnes per year: 25 million tonnes of this goes into the waste management system.
- The build up of products in the regional economy is in the order of 33 million tonnes per year (4 tonnes for every person).

Climate emissions

The second set of findings focuses on the difference between production and consumption, or between regional and global figures for climate emissions (here expressed as CO_2):

- Total CO_2 ***emissions within the region*** are 58 million tonnes per year: about half of this is in private transport and heating of homes.
- Total CO_2 ***emissions due to consumption*** by the region, are 158 million tonnes per year: i.e. the emissions involved in delivering the level of affluence of the South East region.
- Therefore, depending on how the calculations are done, at least 3 times as much CO_2 involved in 'consumption' with impacts spread around the world, as in 'production' within the region.
- ***This shows that current policy targets for climate emissions are at best incomplete, and at worst misleading. The UK is now on course to meet its short term domestic climate emissions targets, while continuing to increase its real impact at a global level.***
- There is an urgent need to standardise EF methods and databases so that a more significant indicator of global impact can be reported at regional and national levels.

Ecological footprint

The next set of findings focuses on the ecological footprint (EF) itself. (This is measured in ‘global hectares per year’, a notional accounting unit for impact which is distributed around the world. The totals here are provisional and subject to resolving questions on double counting and definition of boundaries.)

- The ecological footprint (EF) from all consumption-related activity shows a total of **55 million** global hectares (mgha/yr).
- This equates to **6.8 global hectares per person.**
- This total EF is 29 times the physical land area of the region (1.9 million hectares). This land area equates to _ hectare (2/3 acre) per person, or 0.1 hectare in built up areas (4 persons per acre).
- The largest single component of the total EF is the food/agriculture sector, with 25% of the total. Construction activity takes 17%: commercial services 15%: and transport 21%.

8.10.3 Ecological footprint targets

The analysis of production/consumption and direct/indirect material flow should provide some evidence on how to achieve the Factor Four reductions, where clearly not all sectors are equal to this challenge. As change in each sector involves a combination of social, economic, political, technology and infrastructure factors, we can only suggest where the barriers and opportunities might lie:

- The food sector produces the largest single impact at 25% of EF, and 16% of CO_2. There is great scope for localising food production, reducing energy intensive processing and meat content. This could produce an EF reduction target of Factor 4 or 75% reduction.
- The utilities sector (household and commercial energy and water) is responsible for 17% of total CO_2 emissions, and 12.5% of total EF. Here, while the technological potential for almost zero energy buildings proven, achieving it depends on lifestyles and institutions (for instance for the problem of split responsibilities between landlord, utilities and tenants). In this sector an EF reduction target of ‘Factor 8’ or 87% reduction is suggested.
- Manufactured durables and consumables each show opportunities for demand management, supply chain management, process efficiency, and localised production. In combination these could produce an EF reduction target of Factor 4 or 75% reduction.
- Construction activity is materials and land intensive, but again there is potential for demand management, supply chain management, process efficiency, and localised production, with an EF reduction target of Factor 4 or 75% reduction.
- Commercial and public services show somewhat greater potential for integrated resource management than households. In these sectors an EF reduction target of ‘Factor 8’ or 87% reduction is suggested.
- The transport sector is responsible for 21% of total EF and 27% of total CO_2 emissions, (including freight transport). Growth is partly due to social equity and cohesion, at the local and global scale, and where there are few alternatives to energy intensive technologies: this is

particularly the case for air travel. So there is a case for less stringent targets, combining social equity with technological innovation. In this sector a EF reduction target of Factor 2 or –50% is suggested.

The various targets and change rates for each sector are summarised in the chart and table below. These are put in terms of 'per capita', i.e. not including for the current population growth curve of nearly 1% per year, or 35–40% increase by 2050. Each of the total EF targets would be moderated by this change.

Even so the overall targets for 2050 may look extremely challenging. However 50 years is a long time. So the table also shows at the right hand side, the '2020 Factor of change', in other words at the horizon of many current plans and strategies. This shows that most of the sectors are aiming at a Factor 1.7, in other words a challenging but not impossible rate of progress.

It is very relevant that the South East Regional Waste Strategy shows a very similar or even greater rate of change. This is based on a detailed assessment of policy targets, technology improvements and behaviour changes. The waste sector is outside the accounts above, as waste proportions are built into each of the other sectors. However there is a strong conclusion – if the waste management sector can do it, why not other sectors?

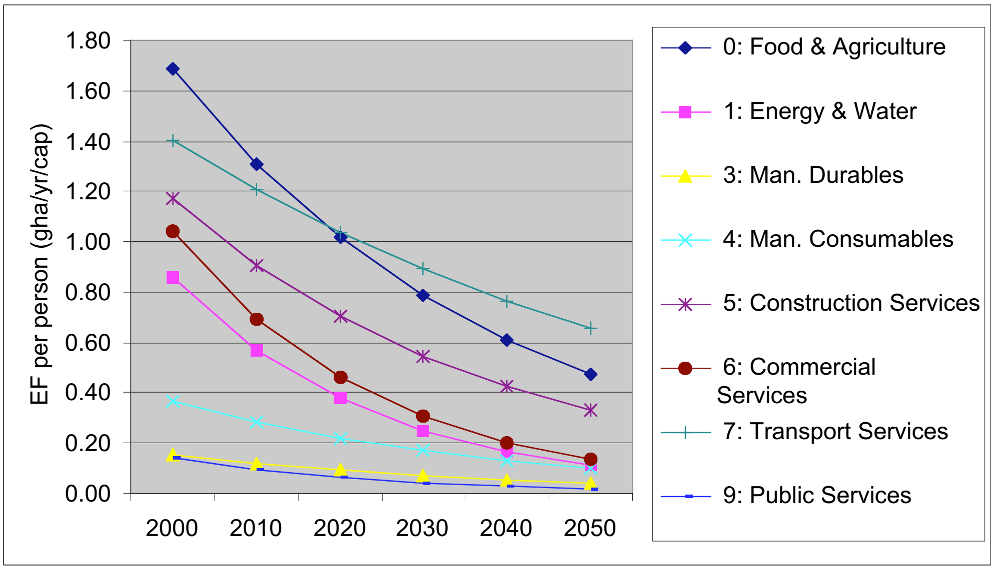

Figure 8.18 Factor Four scenario and EF targets for each sector

Table 8.10.1 Factor Four scenario and EF targets for each sector

	2000	2010	2020	2030	2040	2050	reduction target	annual growth	2050 Factor of change	2020 Factor of change
0: Food & Agriculture	1.69	1.31	1.02	0.79	0.61	0.48	72%	-2.50%	4	1.7
1: Energy & Water	0.86	0.57	0.38	0.25	0.17	0.11	87%	-4.00%	8	2.3
3: Man. Durables	0.15	0.12	0.09	0.07	0.06	0.04	72%	-2.50%	4	1.7
4: Man. Consumables	0.37	0.28	0.22	0.17	0.13	0.10	72%	-2.50%	4	1.7
5: Construction Services	1.17	0.91	0.71	0.55	0.42	0.33	72%	-2.50%	4	1.7
6: Commercial Services	1.04	0.69	0.46	0.31	0.20	0.14	87%	-4.00%	8	2.3
7: Transport Services	1.40	1.21	1.04	0.89	0.77	0.66	53%	-1.50%	2	1.4
9: Public Services	0.15	0.10	0.06	0.04	0.03	0.02	87%	-4.00%	8	2.3
Total EF per person [units in gha/yr/cap]	6.8	5.2	4.0	3.1	2.4	1.9	72%		4	1.7

These overall targets are suggested for further investigation. In no way can they be taken as forecasts. The modelling system which has been developed to test these can hardly cope with the sheer range of possibilities, in technology, society, the economy and politics. So the targets summarised here are simply the result of asking the question – ***'what if'*** the South East region was able to move towards its aspirations for environmental sustainability at the global level.

8.10.4 Integrated resource management and the next steps

The Factor 4 targets above appear strategic in scope and challenging to achieve. Meanwhile the day to day business of running the South East goes on. So the final question is, what can the region do today and tomorrow? There is much detailed advice coming out of the review of each key sector, up to now in this chapter. However there are also common principles which run through each of the sectors. These can be used as directions for regional and local policy, producers and distributors, and consumers and communities.

There are a range of 'models' or general principles, which help to coordinate Material Flow Analysis and Ecological Footprint programmes. These are shown here with 'images' or signposts to examples, to be found in the Taking Stock fact-sheets and other sources.

- ***Strong environmental management model***: this principle puts environmental issues to the forefront, as a driver for economic competitiveness and resource productivity. Where there are 'externalities' of pollution and waste, the business or organisation will aim to account for these. The image comes from the Co-op bank which has put environmental and ethical goals at the top of its agenda, with the result of faster growth than any other.
- ***Evolutionary model:*** the Factor 4 approach to 'dematerialisation' and 'decarbonisation' of the economy will be a shift on a massive scale. It relies on businesses and organisations

anticipating such shifts in their own terms over years or decades, and steering their own evolution to turn potential problems into opportunities. One image comes from the local authority in Woking, possibly the most energy efficient authority in the country.

- ***Service model***: this works on the producer/procurement side, where products are leased, taken back, re-manufactured or recycled, with huge savings in raw materials, processing energy and waste impacts: plus the consumers' facility is continuously updated. The image is one of the new generation of floor covering firms which lease their products rather than selling them.
- ***Social economy model***: this works on the consumer demand side. In many cases there are opportunities to reduce material consumption while increasing human satisfaction, by social trading schemes, equipment banks, lift sharing, and social cohesion in general. The image comes from the car-sharing club at the BedZed development in Surrey.
- ***Integrated resource management model***: this brings each of the above together, and aims to provide the infrastructure to make it work. Such infrastructure can be 'hard' pipes and wires, and/or 'soft' organisations and networks. The image comes from Copenhagen, where over 90% of the construction waste is recycled within the city.

8.10.5 Implications for the region

In terms of scope for action, it is clear that the current structure of governance in the English regions is often partial and compromised. The regional assemblies and development agencies between them manage a small percentage of the total public sector expenditure. The South East is a special case, being the largest and richest region, the closest to the hub of London, and at the same time one of the weakest in institutional terms.

The scope of policy influence on integrated resource management is seen in Chapter 6. The main conclusions are that regional strategies for economic development, spatial development, transport, energy, waste etc, each have a very important part to play, along the lines of the general principles above.

The question here is how much this is a regional agenda, and something that the regional organisations can promote. It has to be said that the obvious starting point – consuming less 'stuff' – is apparently opposite to mainstream economic policy and its goal of GDP growth. So the regional agenda here focuses on potential win-win opportunities:

- Promoting innovation in manufacturing technology, to increase productivity with less impact.
- Encouraging industrial clusters with integrated resource management systems.
- Innovation in materials management, to create markets for re-use, recycling and other forms of recovery.
- Promoting retail clusters and networks which encourage service economies, i.e. leasing and hiring for a service level, rather than one-off material purchases.
- Promoting social economy groups and networks for sharing, re-use and recycling, where this is relevant.

However to achieve Factor 4 targets in each of these sectors will be very difficult unless new forms of networks, partnerships and consortiums can be found. At present the fragmentation between sectors, departments and different levels, makes coordinated action very difficult.

These new forms of networks and partnerships are in formation at present, generally on the boundaries between public and private sectors, between private and community/NGO sectors, and between public and community/NGO sectors. Actions to take this agenda forward should focus on these ‘breeding grounds’ for environmental entrepreneurs.

The government has set an agenda and a direction in 2003 with the Sustainable Consumption and Production strategy. At this point it is very general and deserves to be followed through in every sector and at every level, including the regional level. Hopefully the Taking Stock project is a step in that direction.