Sustainable resource use in the motor industry: a mass balance approach

by L Elghali, V McColl-Grubb, I Schiavi and P Griffiths

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This report forms part of the Biffaward Programme on Sustainable Resource Use. The aim of this programme is to provide accessible, well-researched information about the flows of different resources through the UK economy based either singly or on a combination of regions, material streams or industry sectors.

Information about material resource flows through the UK economy is of fundamental importance to the cost-effective management of the flows, especially at the stage when the resources become ‘waste’.

In order to maximise the Programme’s full potential, data is being generated and classified in ways that are consistent both with each other, and with the methodologies of other generators of resource flow/waste management data.

In addition to the projects having their own individual means of dissemination, their data and information will be gathered together in a common format to facilitate policy making at corporate, regional and national levels.

Members of the Motor Advisory Group:

Richard Smith (Chairman)	Viridis
Graham Armstrong	Automobile Association
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Executive Summary

This document sets out the key findings, conclusions and recommendations of the Biffaward motor industry mass balance study. The report outlines the total material resource flows relating to the entire UK motor industry, from manufacture through vehicle use, to the final disposal of end of life vehicles. The report identifies the waste and emissions associated with the industry within the UK. This is the first time that such a comprehensive study to document resource flows in the industry has been attempted.

Wherever practicable existing definitions have been adopted to assist with the identification and categorisation of products. This is in order to maintain transparency and facilitate comparison with other analyses throughout the motor industry. The report has taken the motor industry to include the following vehicles:

- Cars and taxis.
- Light goods vehicles (LGVs).
- Heavy goods vehicles (HGVs).
- Buses and coaches.
- Motorcycles.

The motor industry mass balance study has identified and quantified the natural resources used, and the wastes and emissions produced by the industry in the UK during 2000. This provides a strategic overview of the resource issues to allow planning for continuous improvements in sustainable resource use in the motor industry.

Historically, approaches to achieving this objective have tended to be focussed at the individual company level, leading to a fragmented approach within the industry generally. However, a number of legislative requirements driven by the concept of 'producer responsibility' will require an industry level approach and a greater degree of collaborative activity than has been the case to date. The mass balance data in this report are useful in providing high level information on resource use, so that suggestions can be made for improvements in industry practices in the future.

This report presents a comprehensive overview of resource flows through the industry. It then considers future trends and influences, and makes recommendations as to how resource productivity can be improved.

The main findings

Addition to the motor industry stock

The addition to the vehicle stock of the motor industry in 2000 was 0.69 million tonnes.

Resource use

To achieve the production of vehicles and components required in 2000, 4.00 million tonnes of primary products were required, plus 3.08 million tonnes of imported components, 0.15 million tonnes of ELV components sold for reuse and 0.72 million tonnes of fluids. This gives a total of 7.23 million tonnes of products used in the production of new vehicles and components, of which 4.90 million tonnes were incorporated into the production of new components and vehicles in the UK (of which 2.64 million tonnes was exported).

To examine the industry's resource efficiency in manufacturing outputs, this can be expressed as a percentage and is given by:

$$\frac{\text{Mass of products manufactured by the motor industry}}{\text{Total material requirement of the motor industry}}\%$$

Calculated in this way, the UK motor industry's resource efficiency in 2000 was calculated to lie in the range 55 to 60%[1].

Energy use

In addition to material resources, energy equivalent to 41.37 million tonnes of oil equivalent is used each year in the manufacture of parts and vehicles and the use of vehicles. The largest consumer of energy is vehicle use, accounting for 96% of the total energy use in the motor industry, for which car use was the most significant contribution.

The energy used during the maintenance of vehicles and management of end of life vehicles has not been addressed in this study.

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[1] *Two figures for total material requirement were obtained by using different data sources. The reasons for this are explained further in Sections 2.1 and 2.2.*

Wastes

Waste arisings from the motor industry have been quantified using a variety of data sources[2]. The majority of waste data presented in the report relate to solid wastes. Some data on 'special waste' produced by the industry were also identified, which included some liquid waste.

In aggregate, the motor industry produced 7.21 million tonnes of waste in 2000, including waste from production, maintenance activities, use and end of life vehicle arisings. This is equivalent to each person in the UK annually producing 0.12 tonnes of waste. This can be thought of as adding an extra 20% to the waste produced by each person over and above the total produced as household waste in the UK.

Emissions to air

Emissions to the air from the motor industry in 2000 totalled just over 122.21 million tonnes. 119.69[3] million tonnes was from vehicle use alone, which is responsible for 23% of the total UK output of the air emissions quantified. If the vehicle use emissions are expressed in terms of their global warming potential, this is equivalent to 119.97 million tonnes of CO_2 equivalents, which represents 17 % of the total for the UK in 2000.

The following table provides a snapshot of the motor industry in 2000. These figures do not include motor vehicle use.

Data availability

This study has quantified the UK motor industry's use of UK energy resources and material resources, both indigenous and imported. It does not however reflect the total impact of vehicle production and use in the UK on global energy and material resources. This is because the impact of manufacturing vehicles outside the UK for use within the UK has not been quantified. The total impact of the UK motor industry on global energy and material resources is therefore understated.

A profile of UK motor manufacturing in 2000

Parameter	*Quantity*
Percentage share of UK total manufacturing turnover[1]	9.1%
Employees directly dependent on the automotive sector[1]	849,000
Resources used (excluding use)[2]	7.23 Mt
Energy used (excluding use)[2]	1.45 Mt oil equivalent[3]
Emissions to air (excluding use)[2]	2.52 Mt[4]
Waste produced (excluding use)[2]	3.58 Mt

[1] SMMT, 2003b.

[2] Data calculations presented in the report (see Chapter 2).

[3] This is equivalent to 0.9% of the total used by the UK in 2000 (see Chapter 5).

[4] This is equivalent to 0.4% of the total used by the UK in 2000 (see Chapter 6).

A similar approach has been adopted with regard to wastes and emissions. The wastes reported are those associated with UK manufacture, use and disposal of motor vehicles (whether for domestic or international markets). The figures quoted therefore do not reflect the impact of the UK motor industry on the waste management industry globally, but provide a snapshot of the wastes and emissions arising within the UK from the motor industry.

In adopting a mass balance approach it was necessary to identify all resource flows in terms of their mass. While some mass data were available other data had to be converted from alternative units including number, length, area and economic value.

Some sources of data only had information relating to a restricted geographic area. In order to arrive at the required UK wide basis it was necessary to estimate resource flows in these areas using proxy data such as economic data, employment data and population statistics.

Main conclusions and recommendations

This report has illustrated the magnitude of resource use, waste production and emission generation from the motor industry in the UK in 2000. Demonstrating that the industry is continuing to make progress towards implementing more sustainable practices will require reductions across all three parameters.

There is at present no single organisation having been given the responsibility for devising policy, monitoring practices, conducting research and providing best practice guidance on sustainability issues for the motor industry. While acknowledging that progress has been achieved by voluntary actions within the motor industry, there is a need for better strategic direction. A number of

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[2] Solid, sludge and liquid wastes are primarily regulated and monitored by the Environment Agency or equivalent in the devolved administrations under the provisions of waste management legislation. Aqueous wastes are defined as those discharged to sewer by private agreement with a sewerage undertaker, or discharged to ground or surface water under authorisation from the Environment Agency. Therefore in this report, although liquid wastes include some water-based wastes, the description only includes those which cannot be discharged to sewer, ground or surface waters and are sent to waste management facilities for storage and/ or treatment instead.

[3] This figure does not include water vapour generated during combustion. Further explanation is given in Chapter 6.

sustainability issues have been identified in this report which cannot be addressed by industry actors alone and which will require support from additional stakeholders in order to achieve further progress. Recent advances in ‘integrated product policy’ and ‘producer responsibility’ legislation are expected to accelerate progress towards establishing an organisation with the ability to provide such strategic direction in future, which will necessarily include a wide diversity of stakeholders.

Recommendations are made in the report to improve the resource productivity of the motor industry:

- Better monitoring and reporting of resource flows, to enable reporting on changes in resource use.

- Creating new relationships between motor industry stakeholders to create progress towards achieving better resource productivity.

- Invest in and share the results of research to define ‘Design for Environment’ principles for the motor industry, with the objective of increasing resource productivity and reducing reliance on non-renewable or hazardous materials.

- Implementing practical measures aimed at stimulating action across the whole industry to minimise resource use, avoid waste production and maximising resource recovery.

- Implementing practical measures to ensure that adverse environmental impacts associated with vehicle use are reduced.

A number of actions have been identified in the report to help to achieve these objectives, although it is acknowledged that some of them may be perceived as contentious or otherwise difficult to achieve at present. The aim of this report is to highlight a number of key issues which it is considered need to be addressed if resource productivity is to be improved and the industry is to continue to make progress towards improved sustainability.

1 Introduction to the Motor Mass Balance

1.1 Introduction

This document sets out the key findings, conclusions and recommendations of the Biffaward Motor Mass Balance study. This report is entitled 'Sustainable Resource Use in the Motor Industry: a mass balance approach'. The definition and context of these terms within this project is described in Sections 1.2 and 1.3. The report outlines the total material resource flows relating to the entire UK motor industry, from manufacture through vehicle use, to the final disposal of end of life vehicles. The report identifies the waste and emissions associated with the industry within the UK.

Wherever practicable existing definitions have been adopted to assist with the identification and categorisation of materials in order to maintain transparency and facilitate comparison with other analyses throughout the motor industry. The report has included the following vehicles as falling within its definition of the UK motor industry:

- Cars and taxis.
- Light goods vehicles (LGVs).
- Heavy goods vehicles (HGVs).
- Buses and coaches.
- Motorcycles.

Recommendations are provided relating to how material resource management might be improved and the demand for resources reduced in future in the motor industry, based on the research findings.

1.2 Sustainable resource use

'Sustainable development' is a term often used in environmental policy formulation. It originated in a document published in 1987, 'Our Common Future', by the World Commission on Environment and Development (WCED). This is the most commonly referenced definition, which states that

> *'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'*

This is a useful statement of intent, involving taking action across three spheres of experience to effect positive changes in conditions for people and the natural environment:

- Economic.
- Environmental.
- Social.

However, it is often a little more difficult to define what actions will assist in making progress towards sustainable development. In practice, is usually easier to define what sustainable development is not, rather than what it is. For example, the economic losses associated with the use of road transport may be viewed as aspects of the UK Motor Industry which are unsustainable. The four main sources of such losses have been estimated on an *ex-post*[4] basis as follows (Mumford, 2000):

- Congestion (£18 billion).
- Accidents (£3 billion). By contrast, the Government valued these losses at £16.96 billion in 2000 (DfT, 2000a)[5].
- Air pollution (£3 billion).
- Noise pollution (£1 billion).

Readers of this report may agree to prioritise these issues for action or may have an alternative list[6]. For example, the UK Royal Commission on Environmental Pollution (RCEP) has produced two reports on sustainability in transport, which defined a number of actions required to ensure that UK transport became more sustainable. Box 1.1 lists the actions identified, which apply directly to the motor industry by implication, as the major transport provider in the UK. To address such problems, attention must be paid to defining the interlinked economic, environmental and social effects requiring action. To take congestion as an example, this has the following negative effects which need to be minimised (the list is indicative only and not exhaustive):

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[4] *That is, 'after the fact', in that the cost of the four parameters was estimated based on published economic data for 1999.*

[5] *Government values include both fatal and non-fatal casualties and have been based on a consistent willingness to pay approach since 1993. This includes some additional aspects of the valuation of casualties, including the human costs and the direct economic costs (i.e. an amount to reflect the pain, grief and suffering and the lost output and medical costs associated with road accident injuries). For this reason, the method encompasses elements of an ex-ante rather than ex-poste evaluation, which is the reason for the discrepancy between the figures quoted. The DfT figure rose to £17.76 billion in 2002 (DfT, 2002a).*

[6] *There are a number of moral and practical arguments surrounding the economic valuation of non-monetary external costs and benefits. In the report, this does not imply that this is the only means of valuation available, or that the derived list is composed of the most urgent problems facing the UK Motor Industry. They are used to illustrate the general approach to sustainability issues in the report.*

Box 1.1 Recent reports on transport and sustainability

The motor industry contributes heavily to the provision of transport in the UK. The Royal Commission on Environmental Pollution (RCEP) provides advice for the government on environmental policy and has produced two reports on reducing transport's impact on the environment. The first report entitled 'Transport and the Environment' (RCEP Report No 18, 1994), reviewed the environmental effects of transport systems and proposed eight objectives for a sustainable transport policy. These were to:

- Ensure that an effective transport policy at all levels of government is integrated with land use policy and gives priority to minimising the need for transport and increasing the proportions of trips made by environmentally less damaging modes.
- Achieve standards of air quality that will prevent damage to human health and the environment.
- Improve the quality of life, particularly in towns and cities, by reducing the dominance of cars and lorries and providing alternative means of access.
- Increase the proportions of personal travel and freight transport by environmentally less damaging modes and to make the best use of existing infrastructure.
- Halt any loss of land to transport infrastructure in areas of conservation, cultural, scenic or amenity value unless the use of the land for that purpose has been shown to be the best practicable environmental option.
- Reduce carbon dioxide emissions from transport.
- Reduce substantially the demands which transport infrastructure and the vehicle industry place on non-renewable materials.
- Reduce noise nuisance from transport.

The report also recommended that quantified targets be introduced as the basis for a transport policy.

The second RCEP report, published in 1997, found few signs of changes in previous trends and emphasised the need for concerted action to make transport more sustainable.

Sources: Royal Commission on Environmental Pollution, 1994 and 1997.

- Causes opportunity costs to business in terms of time wasted which could be spent on profitable activities.
- Increases energy inefficiency and creates more emissions to air from motor vehicles, causing harm to the environment and to human health (for example, by contributing to global warming, ozone creation, etc.).
- Causes health problems for motorists in terms of exposure to emissions, stress and fatigue, whilst also detrimentally affecting freedom of movement and amenity generally for both motorists and other road users.

Clearly, action to promote sustainability would involve minimising these impacts across the three areas, for example by:

- Encouraging businesses and individuals to use other forms of transport or reduce the need for mobility.
- Minimising energy use and emissions from vehicles by better design of vehicles and using alternative energy sources.
- Finding ways of planning cities better to minimise congestion and to maximise amenity and freedom of movement for all road users.

As such, minimising these losses can be represented as a need to achieve a greater level of sustainability in the motor industry. Instigating actions as described can result in progress towards attaining sustainability in the industry.

In this report, the approach taken has been to focus on resource use issues arising from activities in the UK motor industry. This involved quantifying resources used, energy use, emissions to air and waste production in 2000. Thus 'sustainable resource use' would seek, wherever possible, to:

- Minimise use of materials and energy.
- Minimise emissions to air and waste production.

Note carefully that this definition implies a process of continuous improvement, rather than a static 'yardstick' by which to measure performance. The results from the mass balance describe the magnitude of air emissions, waste prodcution and energy use in comparison with the performance for the UK as a whole, providing a current baseline describing the industry's progress in future (as far as data availability has permitted). From an analysis of different sectoral activities, it is also possible to identify the key resource use issues to be addressed to achieve more sustainable resource use in the industry. From these issues, recommendations are made for actions across the three spheres of experience (economic, environmental and social) to continue making progress towards attaining more sustainable resource use in future.

1.3 The motor industry

For the purposes of this study, the motor industry has been broadly defined as comprising of those industries that have a direct contribution to vehicle manufacture, use and disposal. For the purposes of this study, 'motor vehicles' includes passenger cars, LGVs, HGVs, buses and coaches and motorcycles. This definition excludes specialist vehicles such as those used in construction or agriculture. The 'Motor Industry' is defined as those activities that contribute to the:

- Manufacture, assembly and use of motor vehicles and their parts.
- Manufacture, sale and use of aftermarket components for motor vehicles (i.e. replacement parts).
- Management and final disposal of motor vehicles at the end of life.

This study therefore quantifies the UK motor industry's use of UK energy resources and material resources, both indigenous and imported. It does not however reflect the total impact of vehicle use in the UK on global energy and material resources. This is because the impact of manufacturing vehicles outside the UK for use within the UK has not been quantified. The total impact of the UK motor industry on global energy and material resources is therefore understated.

A similar approach has been adopted with regard to waste and emissions. The wastes reported are those associated with UK manufacture, use and disposal of motor vehicles (whether for domestic or international markets) and the use of motor vehicles within the UK. The figures quoted therefore do not reflect the impact of the UK motor industry on the waste management industry globally, but provide a snapshot of the wastes and emissions arising within the UK from the motor industry.

Investigations have extended to one stage before vehicle assembly to those industries that supply components to manufacturers, including discretionary (non-essential) components. These are known as first tier component manufacturers and will generally be supplying parts solely for the manufacture of motor vehicles. This was thought to be the most practical place to draw a boundary for the study without infringing on other Mass Balance studies under the Biffaward programme such as the Steel Mass Balance (Stevens *et al*., 2004). Although packaging is an integral part of the movements of vehicle components and replacement parts this issue is being addressed directly within other areas of Biffaward's Mass Balance programme. To avoid double counting, packaging has not been included within the scope of this work. The system boundary decisions made in the study are summarised in Table 1.1.

Table 1.1 Summary of motor industry activities included in the definition

Resources used by UK manufacturers in vehicles used within the UK.	Yes
Resources used by UK manufacturers in vehicles used outside the UK.	Yes
Resources used to produce imported vehicles manufactured outside the UK.	No
Resources used by UK manufactured vehicles whilst in use in the UK.	Yes
Resources used by imported vehicles whilst in use in the UK.	Yes
Wastes and emissions resulting from the UK manufacture of vehicles for use within the UK.	Yes
Wastes and emissions resulting from the UK manufacture of vehicles for export.	Yes
Wastes and emissions resulting from the use of UK manufactured vehicles within the UK.	Yes
Wastes and emissions resulting from the use of UK manufactured vehicles outside the UK.	No
Wastes and emissions resulting from the use of imported vehicles within the UK.	Yes

It must be recognised therefore that this study identifies the demands for energy and material resources made by the UK motor industry and selected major impacts of the UK motor industry on the UK environment. It does not set out to quantify the global impacts of the UK motor industry and acknowledges that these are understated in this report.

The principle used to organise and collect the data was the mass balance. Further details on the components of the mass balance data collected and methodology are described in Appendices 1, 2, 3 and 4.

1.4 The mass balance

The underlying principle of a mass balance is the physical law that, within a closed system, the total mass is constant. This states that while there may be a movement of mass or a transformation of mass to different forms, it cannot be created or destroyed. The purpose of a mass balance is to 'balance' the masses of all inputs to an activity with the outputs from an activity. The system studied using the mass balance is a defined unit, either a geographical area or economic sector, over a defined time period (see Figure 1.1).

Further details of the mass balance approach to resource use can be found in the Forum for the Future report 'Mapping UK Resource and Material Flows' published by the Royal Society for Nature Conservation (Linstead and Ekins, 2001).

The mass balance data reported in this document aim to quantify the material resources and energy used in, and key wastes and emissions generated by, the motor industry in the UK in 2000.

The boundaries of the mass balance have been clearly defined in order to make clear the data requirements and to ensure the input and output data could be reconciled. Because of the different characteristics of the activities considered, separate data sources and assumptions have been used in calculations for each stage of the motor industry as follows:

- Vehicle manufacture.
- Vehicle maintenance.
- Vehicles in use and end of life vehicle arisings.
- Energy use.
- Emissions.

Mass balance data is useful in forward planning to encourage better resource productivity. Resource productivity is a measure of the efficiency with which an economy uses energy and materials. If the capacity of the environment to absorb waste and pollution is included, then resource productivity can also be thought of as measuring the economy's ability to produce goods and services relative to its environmental impacts (Cabinet Office Performance and Innovation Unit, 2001). The resource productivity data can be used in three main ways to assist with policy formulation and monitoring activities:

1. Provision of a 'snapshot' of current resource use for a given time period. This allows the main resource use issues to be identified for the system studied.
2. If the mass balance is repeated periodically, it may be used to demonstrate trends in resource use.
3. By identifying a number of technological, economic and social trends affecting resource use in the industry, it is possible to carry out modelling of a number of future scenarios using mass balance data. This can illustrate the future consequences of certain policy choices on resource use.

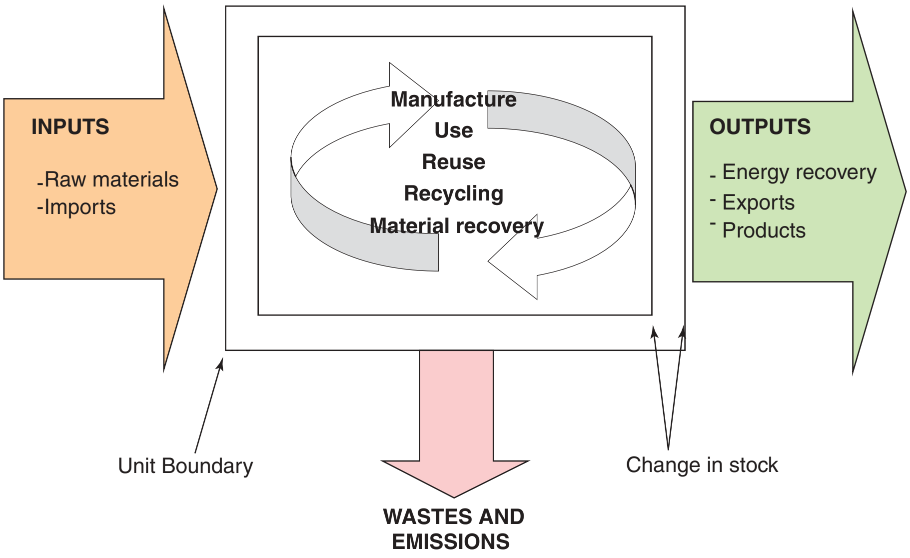

Figure 1.1 Mass balance boundaries

In this report, the second item on the list has not been addressed, as a mass balance has been conducted for the motor industry using year 2000 data only. However, further studies could be undertaken using the same methodology to provide data for subsequent years.

Resource flow indicators are a means of formalising the appraisal of resource productivity. If further analysis is required, the data may also be used within a variety of different methodological frameworks to assess aspects of the sustainability of resource use, including calculating Ecological Footprints (see for example, Best Foot Forward Ltd., 2002).

1.5 The choice of indicators used

The motor industry accounts for 5.3% of economic activity in the UK and employs around 849,000 people (SMMT, 2001, 2003b). Its material and resource uses extend into a wide range of associated industries and the impacts of these industries are experienced across all sectors of the environment. In order to keep the mass balance process manageable it has been necessary to identify key indicators to represent the effects of the industry on resources and the environment.

The World Business Council for Sustainable Development (WBCSD) has identified a limited set of 'eco-efficiency' indicators which it proposes all companies could use for measuring their environmental performance (Verfaillie and Bidwell, 2000). Drawing on these proposals the following indicators were adopted for this study. Some of these equate directly to the WBSCD indicators, others have been adopted as a 'proxy' for the WBSCD indicators. Additional indicators have also been adopted where it was considered significant effects were experienced and could be identified. The indicators selected are:

Generally applicable indicators

- Annual material and product consumption.
- Energy consumption.
- Water consumption.
- Greenhouse gas emissions.
- Transport (vehicle use in this study).

Additional indicators

- Waste production.
- Acidification (acid rain precursors).

The 'generally applicable' indicators of eco-efficiency recommended for use by WBCSD are those for which established definitions and means of measurement methods are available. There is not yet general agreement on how to measure acidification, but once this is established it will have the same status in the opinion of WBCSD as the generally applicable indicators. Acidification potential has been evaluated in this study because motor vehicles in use were known to contribute greatly towards acid gas emissions[7].

The greenhouse gas and ozone depleting substance emissions identified for this study are those selected for the 'basket of emissions' against which reduction targets were agreed at the Third Conference of the Parties of the United Nations Framework Convention on Climate Change in Kyoto (UNFCCC, 1997a, UNFCC, 1997b). These are as follows:

- CO_2 (Carbon dioxide).
- CH_4 (Methane).
- N_2O (Nitrous oxide).
- HFCs (Hydrofluorocarbons).
- PFCs (Perfluorocarbons).
- SF_6 (Sulphur hexafluoride).

The emissions contributing to acidification in this study are identified by Heijungs *et al.* (1992) and were those having quantifiable data available for the mass balance as follows:

- SO_2 (Sulphur dioxide).
- NO_x (Nitrogen oxides).
- NH_3 (Ammonia).

1.6 The issue of 'stock'

The 'stock' of the motor industry is the sum of those elements that make up the total mass of manufactured parts for assembly and aftermarket, vehicle stock and end of life vehicle stock. In order to undertake a true mass balance it is necessary to identify both the 'initial stock' and the 'final stock'. It has been possible to derive the mass of vehicle stock within the UK and end of life

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[7] *This does not imply that there is general agreement amongst environmental management community that the WBSCD indicators are the most appropriate or useful environmental indicators to apply.*

vehicle stock in 2000 with a degree of confidence, since the data available via the vehicle registration system are fairly comprehensive. There is, however, no accepted mechanism for adequately deriving figures for the remaining elements.

Consequently, it was determined that project resources would be better used in identifying the mass data on the material resources used by the motor industry and the wastes and emissions generated by the industry. Assuming that all the relevant resources, wastes and emissions are quantified, and that there are no other losses from the system, the change in stock can be calculated from these data.

1.7 Total resource use

Following on from the foregoing the total resource use of the motor industry identified by this study can be represented by the formula provided in Figure 1.2. Throughout the study, Standard Industrial Classification (SIC) codes have been used as a basis to gather data on resource use, as an accepted means of describing industrial activities.

It is acknowledged that some of the classifications identified as part of the motor industry include materials and products for which only part of the total product sales are used for motor industry purposes. Adjustments have been made to published data where necessary such that the quantities of materials and products identified in this study relate solely to materials used in the motor vehicle industry. The resulting list forms the basis of the database for which motor industry mass balance data have been collected.

1.8 Avoiding double counting

In quantifying the various components of the Mass Balance, care has been taken to avoid double counting of resource use. This has been achieved by identifying the flow of products used through the supply chain through to their incorporation in motor vehicles or to produce replacement parts. This allowed materials which appear in a number of datasets to be identified and included in the mass balance as a single item.

This approach also allows the use of material resources to be directly identified with their end use. Further details of how the issue of double counting has been addressed are given in Chapter 4.

1.9 Wastes

Whereas double counting has been avoided in quantifying material resource use, a different approach is required in respect of waste generation. In quantifying waste generation, wastes generated at all stages of the production of a motor vehicle or replacement product have been included to represent full resource use. Wastes arise in four forms:

- Solid.
- Sludge.
- Liquid.
- Aqueous.

Solid, sludge and liquid wastes are primarily regulated and monitored by the Environment Agency.[8] Where data were available, these types of waste have been included in the mass balance. Aqueous wastes can be discharged under one of two regulatory regimes:

- To sewer under a private agreement between a discharger and a sewerage undertaker.
- To ground or surface water under the terms of a 'consent to discharge' authorised by the Environment Agency.[8] Aqueous wastes are water-based wastes, which are generally discharged to the public sewer system under the terms of a 'trade consent'.

Motor Materials and Products
(SIC 34 and 35.4)
+
Additional Materials and Products
(of SIC 17, 19, 25, 26, 27, 28, 31, 32)
+
Energy used in the Motor Industry
(relating to these SIC Codes)
-
Materials and Products *not* relating to Motor Industry
(Proportions of SIC 17, 19, 25, 26, 27, 28, 31, 32 not relating to the motor industry)

Figure 1.2 Basis of the resource use calculation

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[8] *Or equivalent agency in the devolved administrations.*

These consents are issued by the individual sewerage undertakers and very few record the nature of the industry making the discharge. Accordingly, it has not been possible to identify such discharges made by the motor industry within the resources available to this study.

In addition, the disposal of end of life vehicles is a major component of the mass balance study and as such, the identification of arisings for the different categories included in the study has involved the need for the development of robust methods of measurement. Appendix 4 outlines the methods used to determine the arisings from:

- Cars and LGVs (statutory ELVs)[9].
- HGVs, buses and coaches and motor cycles (non-statutory ELVs).
- Replacement parts and fluids.

1.10 Emissions to air

The greenhouse gas emissions and acid rain precursors were quantified in the mass balance. This allowed reporting against the WBCSD indicators described in Section 1.5. Other emissions have also been reported where data were available.

1.11 Data gaps

There were a number of instances where data on activities, products or materials were not available, primarily due to lack of comprehensive data, or data suppression for reasons of commercial sensitivity. In these instances and where reasonable estimates could be made, the databases were populated with estimates agreed with the project Motor Advisory Group, itself made up of individuals and organisations which represent the industry as a whole. Further details of these estimates are given in the relevant sections. Where it was not possible to make robust estimates the absence of data is noted. Data quality and assumptions are presented in Appendix 2.

1.12 Readership for this document

The document is intended to be of use to a number of interested parties both within and outside the motor industry. The report is based upon a snapshot of information at a given time, providing a baseline scenario from which future research can be carried out. Likely interested parties will include:

- Motor manufacturers and suppliers.
- After-market and replacement parts manufacturers and suppliers.
- Local and national government.
- Motoring organisations.
- Relevant trade associations.
- Consultants and researchers.
- Other non-governmental organisations.

1.13 The structure of this report

This report is presented in 9 chapters as follows:

Chapter 1: Introduction to the Motor Mass Balance

Chapter 2: Key findings on resource use, wastes and emissions

This chapter sets out key data relating to the use of material resources and the wastes and emissions generated by the motor industry.

Chapter 3: The motor industry: infrastructure and legislation

Provides background to the motor industry.

Chapter 4: Resource use (products)

Details the production of parts and vehicles in the motor industry, including an outline of the components to be included. Takes account of after-market and replacement parts issues.

Chapter 5: Energy use

Details the use of energy in the motor industry including energy used during manufacturing, use and disposal.

Chapter 6: Emissions to air

Details emissions of a number of identified gases to the environment by the motor industry including from manufacture, use and disposal.

Chapter 7: Wastes

Details solid, sludge and liquid wastes as produced during the manufacturing process, during vehicle maintenance, and during final end of life disposal. Special Wastes produced throughout the process are also identified separately for production waste only.

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[9] *Statutory and non-statutory ELVs are defined with reference to the ELV Directive (2000/53/EC) in Chapter 3.*

Chapter 8: Trends and influences on the motor industry

Outlines trends and influences that may have an impact upon the future of the motor industry in the UK. Provides quantitative analysis using mass balance data for a number of scenarios where it is possible to do so, and qualitative commentary where this is more appropriate. This provides an overview of issues which will affect the motor industry in the future, including issues of technology, policy and legislation.

Chapter 9: Conclusions and recommendations

Draws a number of conclusions based upon the study and makes a number of recommendations as to how the demand for material resources and the quantities of wastes and emissions can be reduced.

The report also includes references and a Glossary. It concludes with a number of appendices setting out further details of the methodology adopted.

2 Key findings on resource use, wastes and emissions

The UK motor industry draws on a wide range of other industry sectors, some of which rely on the motor industry as their main or only source of business. In the main, there are three main categories of industry involved in whole or in part with the motor vehicle industry. These are industries which:

- Are totally dependent upon the motor industry for their sales (includes producers of car parts and motor vehicle engine oils etc.).
- Are major suppliers to the motor sector, but are not wholly dependant upon it (includes the ferrous and non-ferrous metals sector).
- Make a minor contribution to the motor industry as part of their business activity (includes plastic, rubber and glass).

Other sectors will contribute to the industry to a greater or lesser extent depending upon the general economic state of the country and the identification of other industry sectors in which their products are of use. The SIC system has been used as a means of determining the relevant industry sectors to consider in this study. Further details of the methodology used are given in Appendices 1 and 4. The key figures for resources used, the waste and emissions generated by the industry in 2000 for these activities are illustrated in Table 2.1.

Table 2.1 Resource use, waste and emissions for motor industry activities in 2000

Component and vehicle production (UK only)	*Mass in million tonnes (Mt)*
Material resources used (including components from ELVs sold for reuse and imports)*	7.23
Mass of vehicles and components produced	4.36
Wastes arising	3.58
Vehicle use (all vehicles including imports)	
Addition to stock of vehicle parc	0.69
Material resources used (including imports)[†]	4.35
Energy used (as vehicle fuel)[#]	37.38
Wastes arising[Ψ]	3.63
Emissions to air[♣]	119.69

* *This figure is calculated from the mass of primary products and components consumed in the production of components and vehicles in the UK during 2000. An alternative figure of 7.94 Mt is obtained when this is expressed as the sum of the masses of components and vehicles produced and waste from production. Further discussion is given in Sections 2.1 and 2.2.*

[†] *Excludes oxygen consumed in combustion, included to balance combustion of fuel in the mass balance calculations shown diagrammatically in Figure 2.1.*

[#] *Equates to 39.91 Mt oil equivalents, units used in Chapter 5.*

[Ψ] *Includes tyre rubber and fluids lost during use and ELVs.*

[♣] *Excludes water vapour from combustion, included to balance combustion of fuel in the mass balance calculations shown diagrammatically in Figure 2.1.*

The motor industry activities for which data have been included in the mass balance are broadly characterised as the:

- Production, import and export of motor vehicles and components in the UK.
- Use of UK-produced and imported motor vehicles in the UK.
- Vehicle maintenance activities.
- Management of vehicles at the end of life.

The resource flows for the top level of the mass balance calculated for the motor industry in 2000 are illustrated in Figure 2.1, with explanatory notes in Box 2.1. Figure 2.2 shows the resource flows in more detail between the different activities covered by the study.

2.1 Production and total resource requirement for production activities

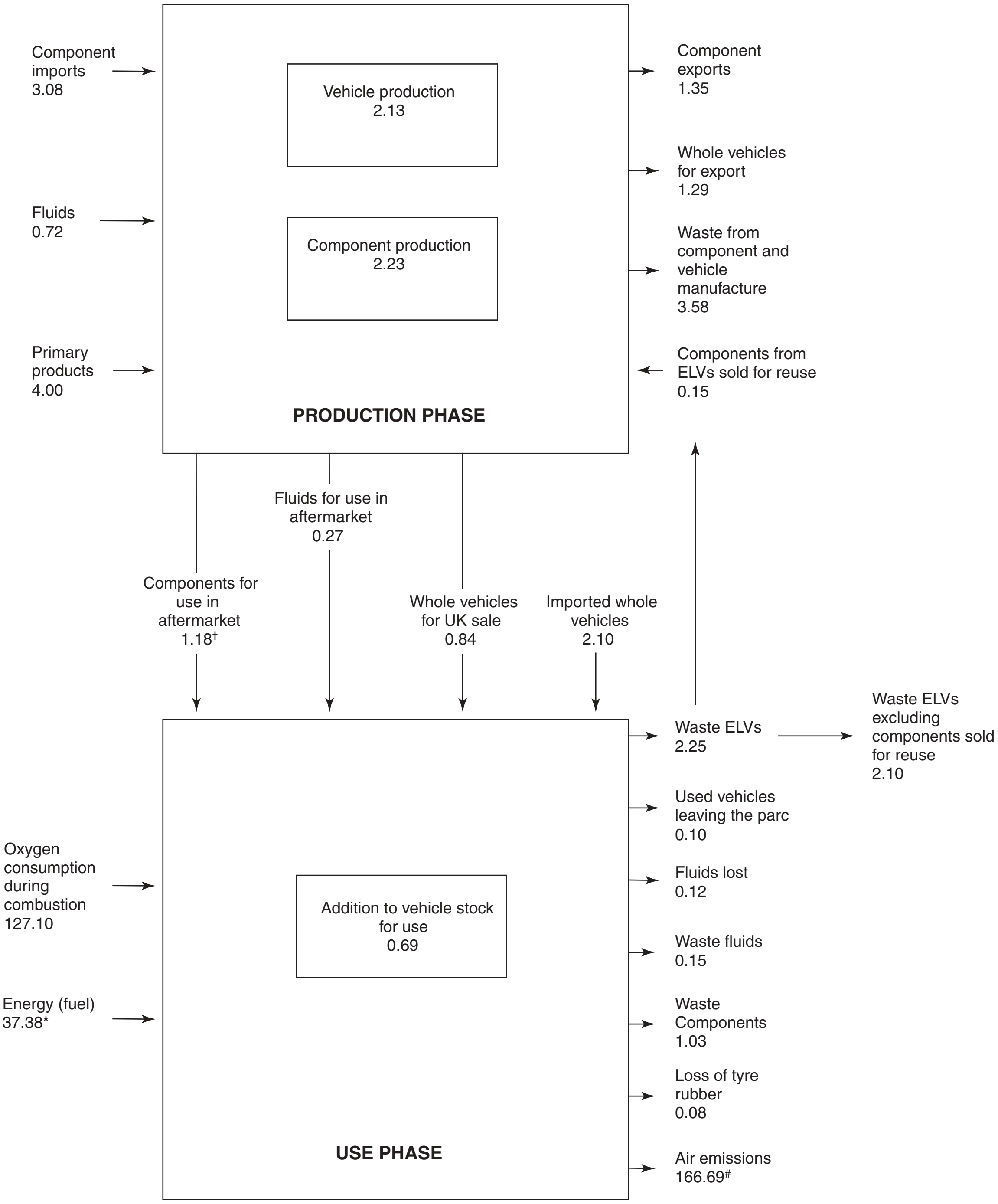
Table 2.2 shows the production figures for the motor industry in 2000. To achieve this production of vehicles and components, 4.00 Mt of primary products were required, plus 3.08 Mt of imported components and 0.15 Mt of ELV components sold for reuse. This gives a total material resource requirement of 7.23 Mt.

Alternatively, the total material resource requirement may be calculated from the sum of the masses of products created (4.36 Mt) and wastes produced (3.58 Mt) by the production stage of the motor industry in 2000. Calculated in this way, the total material resource requirement is 7.94 Mt. There are two possible reasons for this discrepancy. Firstly, the data available to quantify the primary products and components consumed in 2000 is suspected to be an underestimate, due to suppressed and unavailable data (see Figure 2.1 and Box 2.1 for details). Secondly, the figures obtained for waste generated may overstate the mass arising directly from motor industry activities. Detailed explanation of the data sources and calculations is presented in Appendices 1-4.

In addition, 0.72 Mt of fluids were required for vehicle use activities in 2000.

2.2 Efficiency of material resource use

If the efficiency of the industry is defined as the ratio of the mass of products created (as components and



* Equivalent to 39.91 mt oil equivalent.

119.69 Mt of indicator emissions plus 47 Mt water vapour from combustion.

† It has been assumed that the number of components consumed in maintenance is equal to the number of waste components arising (see Chapters 4 and 7).

Note: Numbers do not balance because of differences between data sources. See Box 2.1 for details

Figure 2.1 Mass balance figures obtained for the motor industry in 2000 (Mt)

Box 2.1 Explanatory notes for Figure 2.1

The mass balance diagram

All figures are in units of million tonnes.

The mass balance has been completed in two parts as shown in the diagram. The first part (in the uppermost part of the diagram) shows the mass balance for UK component and vehicle production, with products manufactured in the UK shown in the centre. Product inputs required for manufacturing are shown on the left, with outputs shown on the right and below. Outputs on the right are either wastes generated or are exported products. Those products shown below are incorporated into the second part of the mass balance.

The second part of the mass balance (in the lower part of the diagram) is concerned with the use of motor vehicles in the UK. The inputs are shown on the top and to the right of the diagram, while the outputs are shown on the left. Products used as components, fluids and vehicles are shown along the top. Energy and oxygen resources required to power vehicles in use are shown on the left. Materials lost from the mass balance are shown on the right and include air emissions, waste materials and ELVs (including ELVs not entering processing operations to recover components and materials). Components recovered from ELVs which can be reused in the aftermarket are illustrated as a flow of products back to the mass balance for component and vehicle manufacture.

The resource flows presented in Figure 2.1 do not balance because of differences between data sources. These are discussed briefly below.

Data availability

The calculation of primary products appears to underestimate the industry’s material requirements. When the primary products are back calculated from the mass balance this equates to 4.52 Mt, which contrasts with the figure of 4.00 Mt based on data collected. It is possible that the shortfall in mass could be due to underestimating the component figures, because of suppressed and unavailable data. It is also possible that the waste data obtained from calculations for component and vehicle manufacture may overestimate the mass of waste arisings. Reasons for both observations are discussed further in Appendices 1-4 to this report.

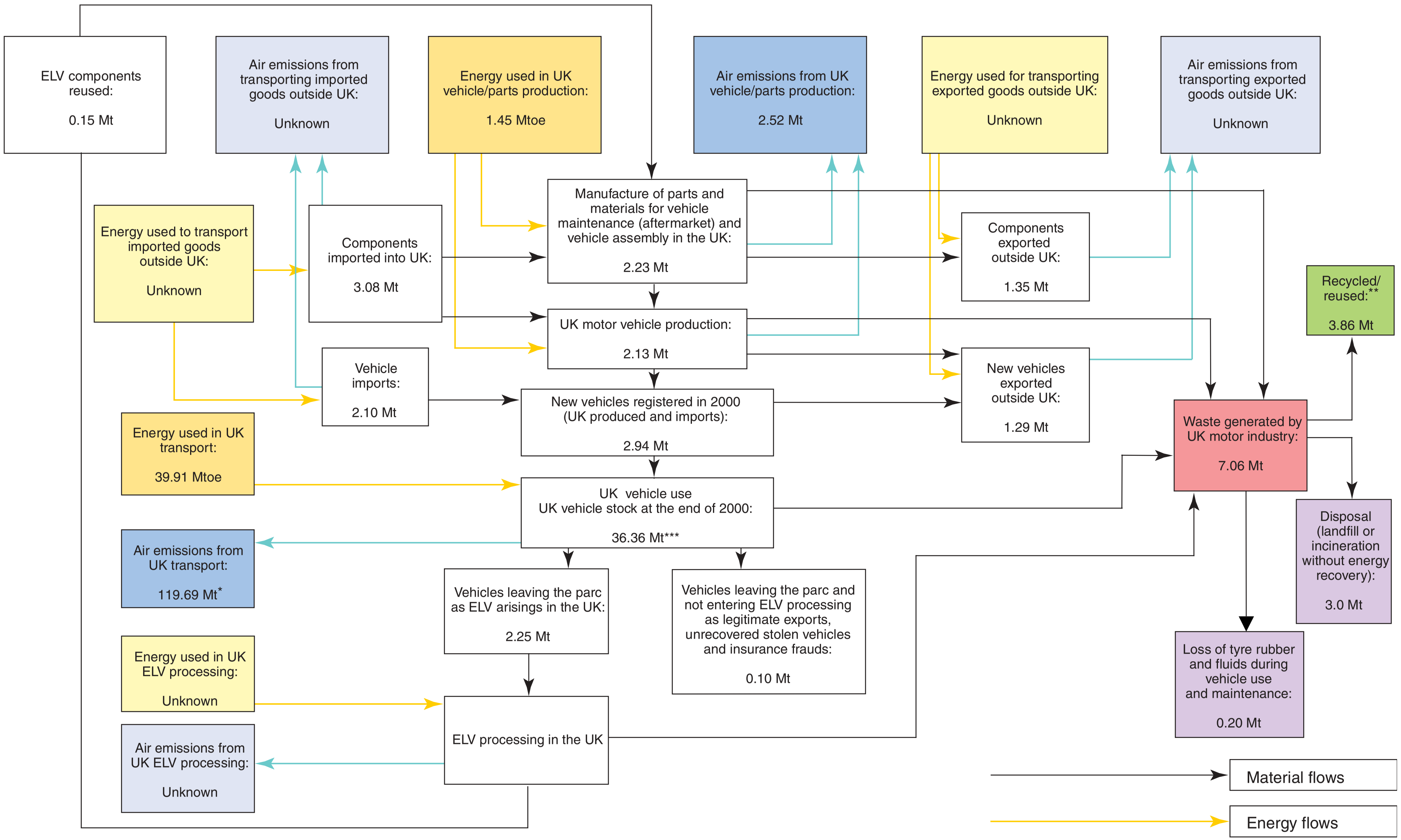
Energy use and air emissions have only been included for the use of motor vehicles. Data were not available to provide enough detail to calculate similar inputs and outputs for component and vehicle manufacture, vehicle maintenance or ELV processing.

The figures presented here for components used in the aftermarket include tyres. The aftermarket should include all products used for activities during the life of the vehicle, including maintenance activities and customisation. However, the figures are based on components replaced during maintenance activities for a year, which will be an underestimate due to omission of aftermarket parts used for vehicle modification. These data were not available. The data include 0.15 Mt of components removed from ELVs for reuse.

It has been necessary to calculate the oxygen consumed and water generated during the direct combustion of fuels by vehicle engines in order to balance the mass of fuel consumed. For this reason, air emissions also include water vapour from combustion.

Air emissions are calculated relative to vehicle types and kilometres travelled, while the energy use figures are from industrial aggregated sources. This accounts for the discrepancy between inputs and outputs in the vehicle use phase.

Used vehicles leaving the parc are defined as those used vehicles which never enter the ELV processing stream. These vehicles may be stolen, legitimately exported or involved in insurance frauds.



* Does not include water vapour from combustion

** Excludes 0.15 Mt of components from ELVs sold for reuse. Indicates waste materials available for recycling and reuse rather than actual quantities recovered.

*** (DTLR, 2000)

Figure 2.2 Resource flows for the motor industry in 2000

Table 2.2 Production and exports of vehicles and components by the UK motor industry in 2000

	Mass (Mt)
Production of vehicles in the UK	2.13 (of which exports 1.29)
Production of components in the UK	2.23 (of which exports 1.35)*
Total UK production	4.36
Of which exports	2.64

* *2.08 Mt new component manufacture plus 0.15 Mt components reused from ELVs.*

vehicles) to wastes produced in 2000, then the resource efficiency of the motor industry is given by:

$$\frac{\text{Mass of products manufactured by the motor industy}}{\text{Total material requirement}}\%$$

$$=\frac{\text{Mass of products manufactured by the motor industry}}{\text{Mass of products consumed in manufacturing processes}}\%$$

$$=\frac{4.36}{7.23}$$

Calculated in this way, the UK motor industry's resource efficiency in 2000 was 60%.

The efficiency of the motor industry manufacturing processes calculated in this way may be overstated, due to the manner of calculating the total material requirement (see Section 2.1). If the alternative figure for the total material requirement is used, then the efficiency calculated is slightly lower as follows:

$$\frac{\text{Mass of products manufactured by the motor industy}}{\text{Total material requirement}}\%$$

$$=\frac{\text{Mass of products manufactured by the motor industry}}{\text{Mass of products manufactured + Mass of wastes arising}}\%$$

$$=\frac{4.36}{7.94}$$

This alternative calculation evaluates the UK motor industry's resource efficiency as 55%.

2.3 Total energy consumption

The total energy consumed by the motor industry in 2000 was 41.37 Mt of oil equivalent. The share of energy used by motor industry activities is shown in Table 2.3.

Table 2.3 Total energy consumed by the motor industry in 2000

	Mass (Mt oil equivalent)	*%*
Total energy used by material and product manufacture (Mt oil equivalent)	1.45	3.5
Total energy used by vehicles in use (Mt oil equivalent)	39.91*	96.5
Total energy used to process end of life vehicles (Mt oil equivalent)	No data available, but assumed small in comparison with above	
Total	41.37	100.0

* *This figure is equivalent to 37.38 Mt of vehicle fuel.*

2.4 Total water consumption

Data were not available to identify the total quantity of water used in the motor industry in 2000. Figures were obtained from manufacturer Environmental Reports on water consumption per car produced. The figures quoted were in the range of 0.16-4.5m^3 per vehicle in 2000 (Honda, 2001, Volkswagen 2002). Due to the range of the figures quoted it was not considered robust to apply these figures to the total vehicle stock. Due to this and in the absence of any other data a figure for total water consumption was not calculated.

2.5 Total waste generated

It was calculated that 3.58 Mt of wastes arose during motor industry production activities in 2000. Further details of products used in 2000 and waste produced are given in Chapters 4 and 7.

The total waste generated by the motor industry in 2000 was 7.21 Mt. This figure comprises waste generated from material and product manufacture vehicle use and waste as vehicles reaching the end of their useful life. Further details on how these quantities have been obtained are provided in Chapter 7. Table 2.4 summarises the sources of wastes generated.

It was not possible to identify water liquid and aqueous waste discharged to sewer, ground or surface waters.

2.6 Total emissions to air

The total emissions to air generated by the use of vehicles in 2000 calculated was 122.21 Mt. This figure can be broken down into the different areas of activity as detailed in Table 2.5. Table 2.6 expresses these emissions in terms of global warming potential and acidification potential. Further details of the types of emissions

Table 2.4 Total waste production by the motor industry in 2000

	Mass (Mt)	*%*
Waste arising from production	3.58	50
Waste arising during maintenance as components and fluids	1.18	16
Waste arising as ELVs	2.25	31
Waste arising during use*	0.20	3
Total	7.21	100
Total available for processing#	7.01	97

* *Fluids and tyre rubber lost during use.*

\# *It is estimated that 4.01 Mt is available for recovery.*

Table 2.5 Total emissions generated by the use of vehicles in 2000

	Mass (Mt)	*%*
Emissions generated during production of components and vehicles	2.52	2.1
Emissions generated during use and maintenance of vehicles*	119.69	97.9
Emissions generated by vehicles at end of life	No data were available	
Total	122.21	100.0

* *Not including water vapour from combustion, included to balance combustion of fuel in the mass balance calculations as shown in Figure 2.1.*

Table 2.6 Total contribution of the use of vehicles towards global warming (as CO_2 equivalent emissions generated) and towards acidification (as SO_2 equivalent emissions generated) in 2000

	Quantity (units)
Global warming potential	119.97 (Mt CO_2 equivalents)
Acidification potential	0.47 (Mt SO_2 equivalents)

quantified and their sources are given in Chapter 5.

To complete the mass balance, it has been necessary to calculate oxygen consumption and water vapour generation during fuel combustion for vehicles in use, to balance the carbon emissions and fuel quantified in the study. The calculations are derived from carbon/hydrogen ratios and the source of data is given in Appendices 2 and 4.

3 The motor industry: infrastructure and legislation

3.1 Vehicle manufacturers in the UK

The UK Motor Industry consists of over 40 manufacturers of cars, vans, trucks and buses and around 7,000 suppliers of automotive components. The vehicle and component manufacturing industry is estimated to have a turnover of about £45 billion. In Europe, Germany, the UK, France and Italy dominate car production along with Japan and the USA from outside Europe. In the UK there are 33 car, 8 commercial vehicle, 1 bus and 3 motorcycle manufacturers sites as listed in Table 3.1. Their locations are shown on Figure 3.1.

3.2 Retail channels for the distribution of automotive parts

In 2001, Market Facts and Business Information (MFBI) estimated that there were a total of 24,440 sites in the UK providing services to replace parts on vehicles. These sites consist of franchised dealers, independent garages, fast-fit operations and autocentres. Independent garages account for approximately 15,000 of these outlets, with franchised dealers accounting for 6,139 outlets (Sewells Franchise Networks, 2000). The remaining approximately 3,000 outlets consist of national service centres, for example fast-fit operations such as Kwik-Fit and ATS Euromaster. In addition to servicing outlets, parts are also supplied via component accessory shops.

Figure 3.1 Location of vehicle manufacturing plants in the UK (2001) *(Source: SMMT, 2001, MCIA, 2004*

Table 3.1 Vehicle manufacturers in the UK

Car manufacturers	
1	AC Car Group Ltd
2	Ariel Motor Company
3	Ascari Cars
4	Aston Martin Lagonda Ltd
5	Bentley & RR Motor Car Ltd
6	BMW (GB) Ltd
7	Bristol Cars Ltd
8	Caterham Cars Ltd
9	Coleman Milne
10	Dare UK
11	Ford Motor Company
12	Ginetta Cars
13	Honda UK Manufacturing Ltd
14	Jaguar Cars Ltd
15	Land Rover
16	Lea Francis Cars
17	Lister Cars
18	Lotus
19	Marcos Sales Ltd
20	Marlin Cars Ltd
21	McLaren Cars Ltd
22	Metrocab (UK) Ltd
23	MG Rover
24	Morgan Motor Company
25	Nissan Motor Manufacturing (UK) Ltd
26	Peugeot Motor Company PLC
27	Reliant Cars Ltd
28	Renault (UK) Ltd
29	Toyota Motor Manufacturing UK Ltd
31	TVR Engineering Ltd
32	Vauxhall Motors Ltd
33	Westfield Sports Cars
Commercial vehicle manufacturers	
(22)	MetroCab Plc
(32)	GM-IBC
34	Dennis Eagle
35	Fodden Trucks
36	LDV
37	Leyland Trucks
38	London Taxis International
39	Optare Group
Bus manufacturers	
40	Wrightbus Ltd
Motorcycle manufacturers	
41	Triumph
42	BSA
43	CCM Motorcycles Ltd

Sources: SMMT, 2001; MCIA, 2004.

The retail channels by which replacement parts are supplied to consumers varies depending on the type of component. An approximate breakdown of the channels by which a selection of common parts are supplied is given in Table 3.2. It is important to note that these figures only relate to the distribution of new replacement parts, and do not include second-hand or recycled components.

Table 3.2 Examples of the retail channels through which new replacement parts pass

	Proportion supplied by				
Component type	Franch-ised dealers	Fast-fit	Indepen-dent garages	Compo-nent acces-sory shops	Other
Brake components	27%	16%	46%	8%	3%
Batteries	8%	37%	30%	10%	15%
Shock absorbers	40%	20%	30%	5%	5%

Source: Datamonitor, 2003

3.3 Recycling parts and materials in the motor industry

UK infrastructure available for ELV processing and reprocessing

A vehicle can reach the end of its useful life in one of two ways. It may be damaged so badly that it is declared beyond repair as a result of accidental damage, flooding, fire or theft. Alternatively, it may eventually become irreparable as a result of natural wear and tear. These types of ELVs are termed *premature* and *natural* ELVs respectively.

ELV processing consists of:

- Purchasing/collecting worn out or damaged vehicles in order to repair them or recover reusable parts.
- Buying and/or selling of scrap vehicles and parts.
- Recovering ferrous and non-ferrous metals that are sold for reprocessing (material recovery).
- Reprocessing and disposal of shredded material.

The companies involved are vehicle salvage operators, dismantlers, scrap metal merchants and shredders. Many companies, however, undertake more than one of the above activities.

The main trade associations that cover the facilities identified are:

- Motor Vehicle Dismantlers Association (MVDA).
- British Vehicle Salvage Federation (BVSF).
- British Metals Recycling Association (BMRA).
- National Salvage Group (NSG).
- Autorecyclers Association (ARA).
- National Amalgamation of Salvage Agents (NASA).

Salvage

Insurance companies establish contracts with large salvage operators or third party contractors/auction houses to collect and process premature ELVs. There are two main ‘brokers’ for premature ELVs in the UK. These are:

- NSG Group.
- Universal Salvage.

However, these companies do not necessarily collect all their own premature ELVs, but co-ordinate collection (by either themselves or other companies). The remaining salvage operations are undertaken by a large number of smaller companies.

Natural ELVs are collected both by the companies identified above, and by the large number of smaller salvage operators and dismantlers located throughout the UK.

Dismantling

The number of dismantlers and scrap yards that are members of one of the trade associations in each government planning region is shown in Figure 3.2 (452 in total). However, it is known that many remain unaffiliated and estimates of the total number of facilities in the UK have been quoted as high as 4,000 (EA, 2002). The fact that ELVs are often processed by more than one dismantler/scrap yard further complicates this stage of the processing chain. The number of companies dealing with an ELV depends on the location and condition of the vehicle so that it is possible for dismantlers/scrap yards to receive ELVs from either a garage, salvage operator, another dismantler/scrap yard or the general public.

ELVs undergo a number of processes at the facilities. The first step is to remove a number of fluids or items regarded as hazardous or potentially harmful to the environment, known as depollution. This involves the removal of:

- Gearbox oil and engine oil.
- Fuel (petrol or diesel).

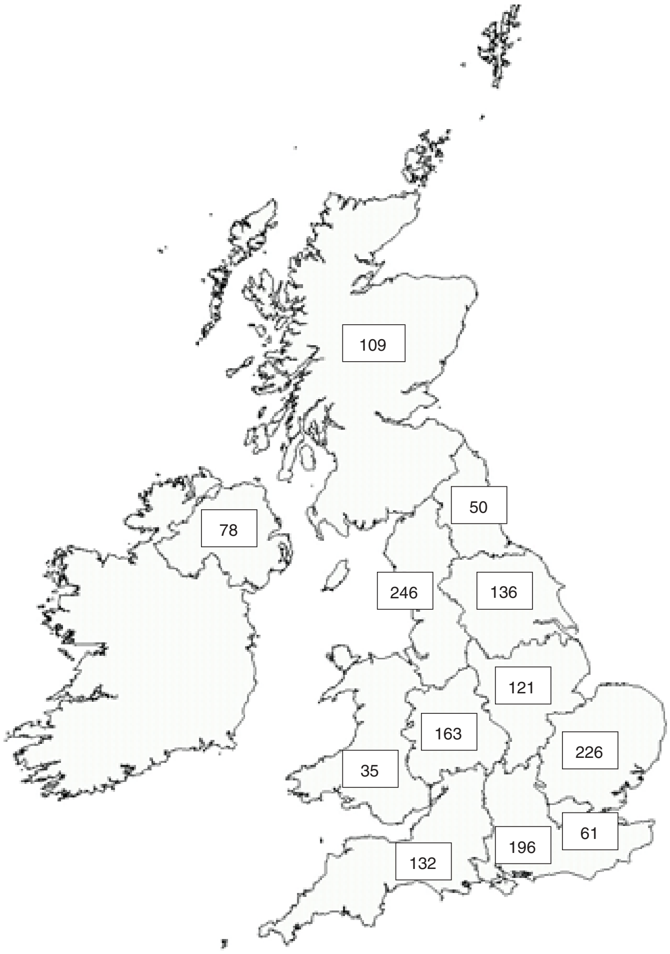


Figure 3.2 Distribution of vehicle dismantlers and scrap yards affiliated to a trade association *(Source: Kollamthodi et al., 2003a)*

- Batteries.
- Radiators.
- Brake fluid and coolant.
- Catalytic converters.

Other parts may then be removed for resale. Parts are either removed immediately and kept in storage or the vehicles are kept in storage and a part removed only when requested by a customer. Vehicles whose parts have no further commercial value for resale of parts are subsequently flattened and taken to shredders for further processing[10]. In some cases, dismantlers/scrap yards may have equipment for further processing such as crushing or baling. This makes transporting the ELVs to the shredder more efficient.

Some components, such as steel wheels, may be removed and sold separately for a premium. This is because, unlike ELVs, they are a pure stream of steel and are therefore of more value to the shredder. Not all parts kept in storage are eventually sold as demand may drop off in which case they are disposed of with the rest of the scrap.

The oil removed during depollution is either used for heating on site or collected for reprocessing in one of three ways:

1. *Fuel production:* This is the simplest process, and involves removing water and solid contaminates.
2. *Re-refining:* This produces a recycled base stock hydrocarbon. A number of processes are available but the two companies in the UK use processes which produce a new recycled oil, water and a residue. The residue can then be mixed with other oils for the production of fuel oil.
3. *Laundering:* This is the reuse of oil as oil refinery feedstock. The treatment is less intensive than re-refining and is used on oils of known composition, such as hydraulic oils and cutting oils. After treatment the oil is returned to the company that supplied it for reuse.

The same companies that collect the oil often collect brake fluid, coolant and fuels for disposal although some dismantlers/scrap yards sell or donate fuels to their staff. Batteries are collected and recycled to recover their lead component while radiators are recycled to recover the valuable copper contained within them.

Tyres from ELVs are either removed at the dismantler or scrap yard or processed with the rest of the vehicle by the shredder, to ultimately be landfilled as part of the shredder residue. Depending on condition, tyres removed by dismantlers are either resold as ‘part-worns’ or collected for a fee by a waste tyre collection company. After collection, waste tyres will follow one of six possible pathways:

- *Retreading:* the worn tread is removed and a new strip of rubber overlayed and remoulded.
- *Recycling:* tyres are made into crumb rubber and used for a number of applications such as in road surfacing.
- *Engineering:* tyres are used for a variety of uses including as drainage layers and daily cover for landfill.
- *Incineration with energy recovery:* mainly in cement kilns.

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[10] *In the case of a detailed study at Overton Dismantlers, they were found to take such vehicles to a local shredder (John Lawrie) for £22 per tonne (Kollamthodi et al., 2003a)*

- *Landfilling:* The EU Landfill Directive has banned the landfilling of shredded tyres from 2003 and whole tyres from 2006.

- *Export.*

Other materials can be recovered from vehicles but at present there are limited market outlets for reprocessing and hence it is not always commercially viable to recover or reprocess these materials. These materials include textiles, plastics and glass.

Vehicle shredding to separate metals for reprocessing

There are 37 shredders within the UK that process ELVs arising in the UK, and 4 heavy media separation plants. ELVs are shredded (often in combination with other sources of metals) and fragments sorted into ferrous metal, non-ferrous metal and shredder residue. A shredder is able to recover the majority (up to approximately 95%) of the metal content (ferrous and non-ferrous) of a vehicle by its magnetic and density properties. The non-metallic fraction (shredder residue) is not currently recycled in the UK, and comprises materials such as plastic, foam, glass, rubber and textiles. This is currently landfilled (Ambrose *et al*., 2001). The locations of these facilities are outlined in Figure 3.3.

The ferrous product from shredders is either exported or sent to one of the following 3 companies in the UK for processing:

- Avesta.

- Corus.

- Allied Steel.

The non-ferrous product from the shredders is either exported or sent to one of four heavy media separation plants in the UK that separate the different fractions of the non-ferrous stream, ready for reprocessing.

Some shredders use an eddy current separator to separate aluminium from the rest of the non-ferrous product. Shredders that are furthest away from the nearest heavy media plant are more likely to use this method of separation in order to cut down on transport costs to the heavy media separation plant. There are between 10 and 12 secondary aluminium reprocessors in the UK. Scrap copper in the UK used to be reprocessed by the copper refinery IMI. However this ceased when the plant closed in 2000.

Small amounts of lead and zinc arise from the shredding of ELVs. These streams are processed in the UK by less than 10 companies. Mixed metal arisings from shredders, such as armatures from starter motors, are exported to India and China for manual separation.

Figure 3.3 Geographical location of shredding facilities (●) and heavy media separation plants (●) *(Source: Kollamthodi et al., 2003a)*

3.4 The extent of vehicle use in the UK

In 2000, there were 28.9 million motor vehicles in use in the UK, of which 24.4 million were cars (DLTR, 2001; DETR, 2001a). Figure 3.4 shows the increase in both vehicle ownership and average distance travelled over the last 10 years. Road traffic is predicted to increase another 17% between 2000 and 2010 (DfT, 1997b; DETR, 2000).

Some of the main environmental impacts of vehicle use are:

- Generation of noise and vibration.

- The use of non-renewable energy resources.

- Production of gaseous emissions, contributing to diverse impacts such as global climate change and poor local air quality.

- Loss of visual amenity.

- Increase in land take associated with road expansion.

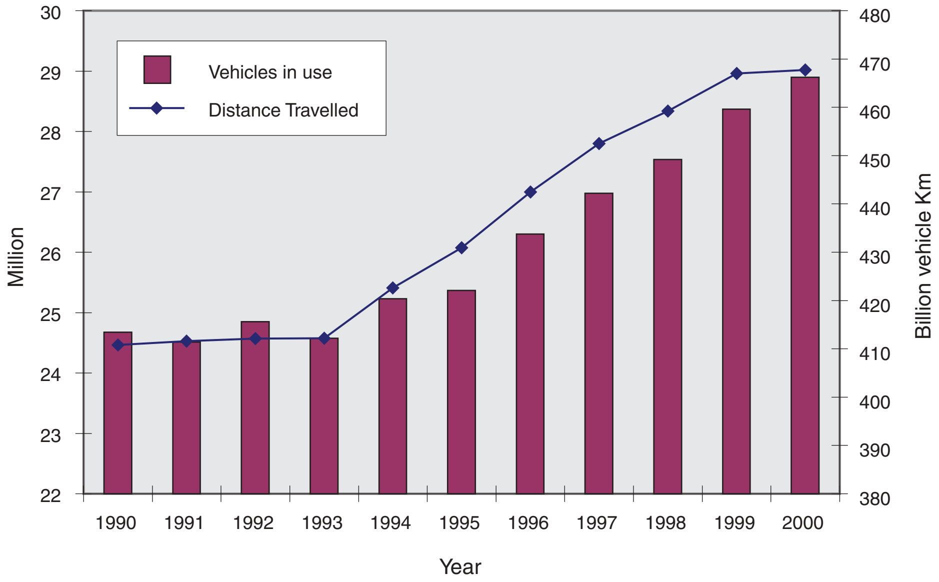

Figure 3.4 Growth in vehicles in use and distance travelled

The latest data on total road traffic volume (DEFRA, 2003a) demonstrate that road traffic has increased from 411 billion to 486 billion vehicle kilometres (18%) between 1990 and 2002, and by 6% between 1998 and 2002. However, road traffic intensity (vehicle kilometres per GDP), fell by 10% between 1990 and 2002 and by 4% between 1998 and 2002, therefore showing some 'decoupling' between road traffic and economic growth. Traffic levels were estimated to be 1% higher in the first quarter of 2003 than in the same period of 2002 - increasing on all road types except major roads in urban areas, where it fell by 2%. There is further discussion on whether it is possible to decouple economic growth and increasing road traffic in Chapter 8.

3.5 Key legislation relating to motor industry activities

This project has been undertaken to determine the resource flows that occur within the motor industry and details the impacts that the industry has upon the UK as a whole in terms of resource use and waste and emission production. These impacts are increasingly being influenced by new legislative drivers that call for improvements in the management of impacts from vehicles. It is not possible within the scope of this document to review legislation applying to all stages throughout the manufacturing, use and disposal of vehicles. For this reason, key environmental issues affecting the industry have been selected and this report has reviewed recent regulatory developments to control them. The issues addressed in this report are listed in Table 3.3.

3.6 Vehicle type approval

Many industrial sectors are subject to technical regulation, but perhaps some of the most stringent legislation has applied to the approval of new vehicles.

Table 3.3 Issues identified for a review of legislative and policy provisions

Key issue addressed	*Reason*
Vehicle Type Approval to ensure that vehicles are safe, fit for purpose and that noise and emissions are kept within acceptable limits.	Covers some key environmental emissions quantified by mass balance and explains some constraints on vehicle design.
Introduction of Integrated Pollution Prevention and Control to certain industrial processes.	Has far reaching implications for industrial practice. Controlling VOC emissions from spray painting processes is described as an example.
Improving waste management practices by introducing relevant waste regulation to the industry.	Waste minimisation and recycling continue to drive environmental policy in the industry and are important in promoting resource efficiency.
The introduction of specific provisions to address the management of ELVs.	At the time of writing, this is the most recent policy development to introduce the principle of producer responsibility to the vehicle industry.

Ever since motor vehicles began to be produced, they have been subject to such technical regulation, because of the two main areas of concern with their impact on society:

- Safety of the vehicle in use for all road users.
- The potential to adversely affect the environment and human health via excessive noise and emissions.

In Europe, two systems of type approval have been in existence for over 20 years. One is based around European Directives and provides for the approval of whole vehicles, vehicle systems, and separate components. The other is based around ECE (United Nations) Regulations and provides for approval of vehicle systems and separate components, but not whole vehicles.

Both systems require third party approval: testing, certification and production conformity assessment by an independent body. Each European Member State is required to appoint an Approval Authority to issue the approvals and a Technical Service to carry out the testing to the Directives and Regulations. An approval issued by one Authority will be accepted in all the Member States. The Vehicle Certification Agency (VCA) is the designated UK Approval Authority and Technical Service for all type approvals, which includes:

- All cars (including low volume production).
- LGVs and HGVs.
- Trailers.
- Motorcycles.
- Cranes.
- Agriculture and forestry tractors.
- Special purpose and off-road vehicles.

Further details of the type approval process are given on the VCA website (www.vca.gov.uk).

Given the focus of this report on sustainable resource use, some aspects of type approval relating to control of emissions are presented here in more depth.

Control of vehicle emissions in EU type approval legislation

Emissions from vehicles controlled by the vehicle type approval process are stringently controlled and the limit values in EU legislation have steadily decreased over the last ten years. A broad outline of how this was achieved is given in this section, but a more comprehensive account is provided by McCrae and Green, 2003. The exhaust emissions controlled in this way are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x), and for diesel vehicles particulates (PM). Emissions from vehicles may be regulated by specifying the composition of the fuel and/or by specifying the characteristics of the vehicle itself. In practice, a combination of these factors is often used to meet emission limits. Before most new models may enter the market, an example is subjected to a test procedure and its emissions must be shown to fall within specified limits. Here, some of the specific emission limits relating to cars and are presented.

The earliest emission legislation was introduced into the UK through compliance with EU Directive 70/220/EEC, which specified limits for CO and HC for light duty vehicles (vehicles with a gross vehicle weight (GVW) of less than 3.5 tonnes). Over time, a number of legislative changes were made. Directive 74/290 introduced lower limits for CO and HC, and a standard for NO_x was introduced under Directive 83/351/EEC. In addition to further reductions in the allowable limits, the methods of sampling and analysis of HC were changed, and for the first time the Directive became applicable to diesel and well as petrol-engined vehicles.

During the late 1980s, a further series of amendments were made over a relatively short period. Directive 88/436/EEC set new, lower limit values based on the vehicle's engine capacity (rather than mass, as in previous Directives), Directive 88/436/EEC introduced a particulate mass limit for diesel vehicles, and Directive 89/458/EEC further reduced the limit values for small cars (engine capacity below 1.4l) and announced the intention to modify the emission test cycle to include a higher speed element. The cumulative effects of these amendments were consolidated in Directive 91/441/EEC, which represents a key stage in the development of the legislation. Briefly, its content was as follows:

- The same emission limit values apply to all cars, irrespective of weight or engine capacity.
- The test cycle combines the original urban cycle with a higher-speed, extra-urban cycle.
- Improved measurement procedures, and reduced limit values are specified for diesel particulates.
- Durability requirements are included: a number of optional methods are available by which to test the effectiveness of the emission control technology over an extended period of service.
- Evaporative hydrocarbon emissions are restricted and a test procedure is specified.

This combination of requirements had a fundamental effect on the technologies needed to satisfy the standard. The limit values were such that they could only be achieved by diesel engined cars or petrol-engined cars equipped with catalytic emission control systems, and the limit on evaporative emissions meant that they had to be controlled, by the use of carbon traps on the vehicle.

Thus, while the previous amendments to the standards had produced successive, rather small improvements in the emission characteristics of the vehicles to which they applied, the technology changes necessitated by Directive 91/441/EEC implied a single large step change. A properly operating three-way catalyst is easily capable of reducing the emissions from a petrol vehicle by 80 %. Generally the limits applicable to the 91/441 Directive are known as the Euro I standard, with those limits in place before the implementation of Euro I referred to as the Pre-Euro limits. Some of the Euro I emission standards, and their subsequent amendments are shown in Table 3.4.

Directive 93/59/EEC extended the provisions of the Euro I standard to light commercial vehicles (< 3.5 tonnes) and other passenger cars falling outside the original Euro I vehicle definitions.

Euro II standards were introduced through Directive 94/12/EEC. Separate limits were established for diesel engines, separated into direct and indirect injection technologies. The Euro II limits were extended to light commercial vehicles under Directive 96/69/EEC.

Directive 98/69/EEC further tightened previous Directives, with the establishment of two further emission limit revisions for 2000 (Euro III) and 2005 (Euro IV). Although these proposals were initially independent, the Directive covers light commercial vehicles, as well as petrol and diesel passenger cars. In addition to a tightening of the allowable emission limits, the Directive made provision for new frameworks for vehicle recalls based upon in-use emission test failures, the imposition of on-board diagnostics (OBD) on both diesel and petrol vehicles, the additional use of fiscal policies to encourage the introduction of cleaner fuels, the enhancement of the cold start requirement and changes to the durability specifications for emission control equipment.

Other categories of vehicle are also subject to European emission control standards, and have seen legislative developments similar to those for cars. Light commercial vehicles of less than 3.5 tonnes GVW were included in the categories covered by Directive 70/220/EEC and its amendments until Directive 91/441/EEC, which is applicable only to cars. Directive 93/59/EEC dealt specifically with light commercial vehicles, and sets limits of similar stringency to those applied to cars. Standards for cars and light commercial vehicles were again harmonised under the terms of Directive 94/12/EEC, from January 1997.

Table 3.4 Vehicles with at least four wheels used for the carriage of passengers not exceeding 2.5 tonnes laden with up to 6 seats

			Limit values (g/km)				*Implementation dates*	
EU Directive	*Engine fuel type*	*CO*	*HC*	*NO_X*	*$HC+NO_X$*	*PM*	*Type approval*	*In-use*
91/441/EEC (Euro I)[1]	P	2.72			1.0		01/07/1992	31/12/1992
	IDI	2.72			1.0	0.14		
	DI	2.72			1.4	0.20		
	DI	2.72			1.0	0.14	01/07/1994	31/12/1994
94/12/EC (Euro II)	P	2.20			0.5		01/01/1996	01/01/1997
	IDI	1.00			0.7	0.08		
	DI	1.00			0.9	0.10		
	DI	1.00			0.7	0.08	01/10/1999	01/10/1999
98/69/EC (Euro III)[2]	P	2.30	0.20	0.15			01/01/2000	01/01/2001
	D	0.64		0.5	0.56	0.05		
	P	*15.00*	*1.80*				01/01/2000	01/01/2001
98/69/EC (Euro IV)	P	1.00	0.10	0.08			01/01/2005	01/01/2006
	D	0.50		0.25	0.3	0.025		
	P	*15.00*	*1.80*				01/01/2005	01/01/2006

[1] Introduction of a new test cycle, the combined urban and extra-urban test referred to as the EUDC (extra urban drive cycle). In addition the legislation defined a limit for idle CO_2 emissions, zero emissions from the crankcase and a limit on evaporative emissions of hydrocarbons from petrol vehicles.

[2] Revision to the 91/441 test cycle to exclude the initial 40 sec idle, thus tightening the cold start performance requirements.

Glossary: P – petrol, D – diesel, DI – direct injection, IDI – indirect direction.

Source: McCrae and Green, 2003.

Legal standards for gaseous emissions from heavy commercial vehicles (GVW > 3.5 tonnes) were introduced considerably later than those for light commercial vehicles. The first Directive, 88/77/EEC set limits for CO, HC and NO_x emissions applicable to UK vehicles from April 1991. This was amended by Directive 91/542/EEC, in which the limit values were changed substantially through a two stage process and a particulate limit was added (Euro I and Euro II standards). Under the subsequent Directive 1999/96/EEC (arising from the Auto Oil programme), these Euro II standards were replaced in 2000 by the Euro III limits. Further changes have already been accepted for the introduction of the Euro IV and V standards in 2005 and 2008 respectively.

3.7 Implementation of the Integrated Pollution Prevention and Control (IPPC) directive

The UK Pollution Prevention and Control Regulations 2000 (as amended) have been in force since 1 August 2000 and implement the IPPC Directive (96/61/EC). One area in which this legislation has had considerable impact in the motor industry is in the use of paints and solvents, and this is discussed here in more detail.

Paints are used primarily on vehicles to prevent corrosion and for aesthetic reasons. However, volatile organic compound (VOC) emissions from solvent based paints during painting activities can pose a risk to the environment and to human health, but are currently being addressed in the motor industry through the use of:

- More efficient paint application technologies.
- Low solvent/water-based coatings.
- End-of-pipe abatement in the form of thermal or catalytic oxidisers.

Box 3.1 illustrates how significant the introducing such measures can be in terms of reducing emissions. The UK Pollution Prevention and Control Regulations 2000 implement the EU Solvent Emissions Directive (1999/13/EC). They mirror the previous regulations in that processes are categorised as Part A (1 and 2) and Part B processes, and are regulated by either the Environment Agency[11] or local authorities, depending largely on the quantities of organic solvents involved in the activity regulated and the degree of risk that the activity poses to the environment and human health. The statutory guidance note 'Paint Application in Vehicle Manufacture 6/20' (DETR, 1997), which was published in March 1997, is in the process of being updated to provide guidance on the phased implementation of the Directive's provisions up to 2006.

Figure 3.5 illustrates the main environmental emissions from the vehicle painting process.

Some developments which are enabling the UK motor industry to adapt to the new legislative standards include:

Box 3.1 Reducing volatile organic compound emissions at Vauxhall's Luton and Ellesmere Port plants

In 2001, total emissions of VOCs fell by 34% to 897 tonnes from Vauxhall's UK plants. Emissions per car produced were reduced by 22% in the period from 1999 to 2001, which is significantly better than the company's self-imposed performance target of a 17.5% reduction by 2003. These reductions can be attributed to the following three factors:

- The final installation and use of waterborne basecoats at the Luton Plant (from May 2001).
- Lower production volumes.
- Further solvent recovery units coming on stream at Ellesmere Port.

In early 2002 Vauxhall's corporate target for VOC emissions from car painting was revised to reflect the closure of their Luton Plant. Unfortunately, this signalled the loss of the benefits of the waterborne basecoat programme at the Luton Plant. The new target applied to the Ellesmere Port Plant alone, where the objective is to keep emissions at the current level following the starting of manufacturing the New Vectra. The New Vectra has a larger surface area requiring more paint and therefore one would expect the process to generate more solvent emissions. When the production of the New Vectra is established, the plant will start to re-examine additional opportunities to reduce solvent emissions further.

Source: Vauxhall, 2001

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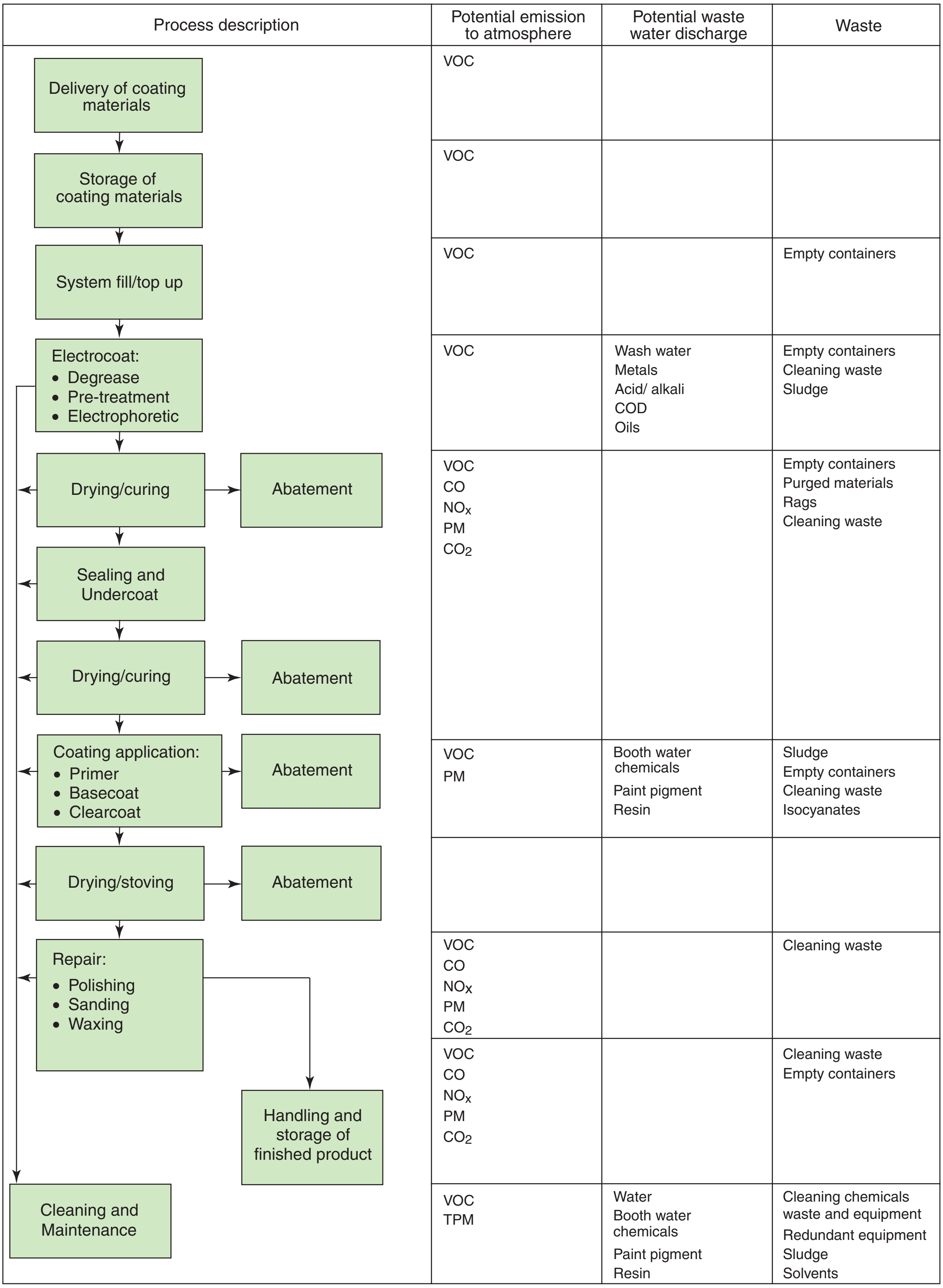
[11] *Or equivelent agency in the devolved administrations.*



Process description	Potential emission to atmosphere	Potential waste water discharge	Waste
Delivery of coating materials	VOC		
Storage of coating materials	VOC		
System fill/top up	VOC		Empty containers
Electrocoat: • Degrease • Pre-treatment • Electrophoretic	VOC	Wash water Metals Acid/ alkali COD Oils	Empty containers Cleaning waste Sludge
Drying/curing Abatement Sealing and Undercoat Drying/curing Abatement	VOC CO NO_x PM CO_2		Empty containers Purged materials Rags Cleaning waste
Coating application: • Primer • Basecoat • Clearcoat Abatement	VOC PM	Booth water chemicals Paint pigment Resin	Sludge Empty containers Cleaning waste Isocyanates
Drying/stoving Abatement			
Repair: • Polishing • Sanding • Waxing	VOC CO NO_x PM CO_2		Cleaning waste
Handling and storage of finished product	VOC CO NO_x PM CO_2		Cleaning waste Empty containers
Cleaning and Maintenance	VOC TPM	Water Booth water chemicals Paint pigment Resin	Cleaning chemicals waste and equipment Redundant equipment Sludge Solvents

Figure 3.5 Potential releases from a typical application of paint in vehicle manufacturing (DEFRA, 2004)

- Reformulating coatings towards water-borne base coats.

- Incineration of the paint drying oven emissions.

- Pigmenting plastics in-mould rather than painting on the colour afterwards.

- Reducing the use of solvent borne adhesives on the assembly line by design innovation.

- Moving to mechanical fixings.

Switching from solvent-based paints to water-based paints is a possible option for reducing volatile emissions. However, costs and difficulties may be encountered in converting solvent paint shops to water-based ones. For example, although water-based paints are used as standard for basecoats, they have not been adopted for clear coats at present because of inferior drying characteristics (Cleaner Vehicles Task Force, 2000).

3.8 Existing waste legislation and its relevance to the motor industry

EU waste legislation framework

The EU is driving much of the waste policy developments in the UK. It has produced a number of Directives relating to Waste Disposal. Up until 1993, these were aimed at harmonising waste disposal policies across EU member states. However, since then, proposals for waste legislation have been based on environmental protection.

The most important EU Directive was the 1975 Framework Directive on Waste that established general rules for waste management. This was amended in 1991 (91/156/EEC) where it defined waste as:

> *'Any substance or object .... which the holder discards, or intends to discard, or is required to discard'.*

At the heart of all EU environmental policy is the concept of 'sustainable development' and, with regard to waste, increasing emphasis has been placed on implementing 'waste hierarchy' principles. In 1996, the hierarchy of principles outlined in the 1989 Community Strategy for Waste Management (COM(96)399) was reaffirmed. The focus of EU policy is to encourage waste management practices at the top of the hierarchy and discourage those at the bottom, which can be listed in order of preference as follows:

- Reduction.

- Reuse.

- Recycling.

- Recovery of materials or energy.

- Disposal.

In order to effect robust implementation of these principles across Member States, there are a number of Directives relating to particular waste streams or sectors. An example is the End of Life Vehicle Directive, which is discussed in more detail in Section 3.9.

UK waste legislation

The first detailed policy framework for waste management in the UK was set out in the 1995 White Paper Making Waste Work. Since then, the Government has published a waste strategy[12] for England (DETR, 2000a). Within this document a number of targets have been set which reflect both targets identified in EC Directives, and some additional ones, including to reduce the amount of industrial and commercial waste going to landfill to 85% of that in 1998. The key principles underlying the Government's waste strategy are listed as follows:

- *The Best Practicable Environmental Option (BPEO)* - the option that 'provides the most benefits or the least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term'.

- *The Waste Hierarchy* - a conceptual framework or guide that places the options in order of priority, starting with waste reduction and followed by re-use, recovery (recycling, composting or energy recovery) and finally disposal.

- *The Proximity Principle* - the principle that waste should generally be disposed of as near to its place of production as possible (recognising that the transportation of wastes can have a significant environmental impact).

- *The Polluter Pays Principle* – the principle that if waste is created, it cannot be passed on or out, but must be treated and paid for by those who create it, adding that existing damage to the environment must be paid for.

The main aspects of waste management legislation applying to wastes and, therefore, to end of life vehicles (statutory and non-statutory) include the following:[13]

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[12] *Parallel waste strategies have been written for the remainder of the UK.*

[13] *As implemented in England and Wales. Implementation varies in Scotland and NI.*

- *Environmental Protection Act 1990, section 33* - This states that it is an offence to deposit, knowingly cause or permit the disposal of controlled waste on land without a waste management licence.

- *Environmental Protection Act 1990, section 34* - This introduced the 'Duty of Care' principle in order to ensure that all those involved in the transfer of waste take responsibility for its safe disposal. This means that it is the responsibility of local authorities, and salvage operators to ensure that contractors and dismantlers are authorised to take waste.

- *Environmental Protection (Duty of Care) Regulations 1991* - These regulations require that an audit trail be created, documenting the entire process of waste management via a system of transfer notes, which state exactly what the waste is (using the European waste classification) and how it should be handled. These transfer notes should be kept for two years and may be required to be inspected.

- *Waste Management Licensing Regulations 1994* - These set out the procedures for obtaining a waste management licence. A typical charge for a licence application is £1,500 to dispose of less than 5,000 tonnes of inert waste in or on land. There is also an annual charge covering the cost of supervision and, in order to get a licence, the licence holder must undergo training.

Every organisation generating waste is required under the Duty of Care Regulations to ensure that any contractors and dismantlers engaged to undertake waste management functions on its behalf are authorised to carry, keep or treat waste.

In 1995, the Waste Management Licensing Regulations were amended to cover scrap metal dealers and motor vehicle dismantlers, where activities include the processing of special waste. There are a number of 'exemptions' from the waste management licensing regime, typically requiring registration with the Environment Agency, SEPA or Northern Ireland counterpart. These include materials:

- Within the 'commercial cycle or chain of utility'.

- 'Material which can be put to immediate use without the need for waste recovery operations'.

- 'Waste which has been processed to such a state that it can be used as a raw material'.

The main purpose of these exemptions is to avoid the unnecessary use of legislation and regulation, but to still meet the overarching objective of minimising harm to the environment and human health. This is intended to encourage the recovery of waste indirectly. It is estimated that there are around 1500 vehicle dismantling businesses currently operating under a Registered Exemption (DEFRA, 2003b).

In addition, the Government plans to use a combination of regulations, economic instruments, research, information and education initiatives to improve waste management practice in the UK. A current key economic instrument is the Landfill Tax, which was first introduced in 1996. The current rate of tax for active waste is £15 per tonne (£2 per tonne for specified inactive wastes), and will increase by £3 per tonne per year in future years. This increase will have a significant affect on the cost of waste disposal by landfill, and is designed to motivate waste producers to reduce waste and to consider options other than landfill (i.e. re-use, recycle or recovery).

Planning Authorities play a key role by facilitating the provision of waste management facilities in line with the new waste strategy. In 1999 revised guidance on waste management and disposal was issued in Planning Policy Guidance Note 10: Planning and Waste Management, known as PPG 10 (ODPM, 2004).

PPG10 sets out good practices for delivering the land use planning aspects of overall waste policy, and defines the roles of the various parties. These include the Regional Planning Bodies (responsible for developing Regional Planning Guidance), Regional Technical Advisory Bodies (responsible for advising Regional Planning Bodies), and the Environment Agency (responsible for providing up to date information on waste arisings and the extent of, and need for, management and disposal facilities).

In addition, there are more stringent legislative provisions for dealing with hazardous materials, which also apply to materials, components and fluids from vehicles (see Box 3.2).

3.9 Specific legislative provisions for end of life vehicles

The EU End of Life Vehicle (ELV) Directive (2000/53/EC) was due to be transposed into UK law by 21 April 2002. The DTI brought the first set of ELV regulations into force in November 2003. These introduced design standards for vehicle manufacturers as well as permitting and environmental standards for dismantling, recycling and disposal of ELVs[14]. In summary the Directive will:

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[14] *The consultation on articles 5 and 7 closed at the end of March 2004. Articles 5 and 7 require the take-back, treatment and recovery of ELVs.*

Box 3.2 Legislation dealing with hazardous components from vehicles

Waste oils, brake fluid, lead acid batteries, airbags and seat-belt pre-tensioners are classified as hazardous waste so their treatment within the ELV processing chain is covered by the Special Waste Regulations.

Regulation 15 of the Special Waste Regulations stipulates that records, in the form of consignment notes, must be kept at the site where the waste is received and where it is consigned to for a period of not less than 3 years. Regulation 16 requires that those receiving the waste keep a record of where it is finally deposited. Under the regulations, all movements of special waste are subject to a £15 fee. Pre-notification must be made at least 3 days before the movement of special waste to the Environment Agency, SEPA or Northern Ireland equivalent. Once the permit has been revoked or surrendered these records and consignment notes get sent to the Environment Agency or SEPA and placed on a public register. The Special Waste Tracking System (SWAT) holds all the information and is used for statutory reporting requirements, planning, waste strategy and enforcement purposes.

Many of the ELVs entering shredding facilities may contain significant quantities of potential environmental pollutants. ‘The shredding industry has estimated that up to 40% of the vehicles that are shredded still contain significant quantities of these potential environmental pollutants’ (Ambrose *et al*. 2001). These included materials such as used lead acid batteries, lubricating oils, brake fluid, coolant, fuel and tyres. However, since January 2002 an untreated ELV is classified as hazardous waste under the European Waste List (EWC 160104). For this reason shredding facilities are beginning to demand that depollution activities are carried out before vehicles will be accepted for shredding (unless facilities are available to depollute vehicles on site).

Waste airbags that have not been deployed fall within the Explosives Act 1875 and so are not covered by the Special Waste Regulations.

Sources: Special Waste Regulations 1996 (as amended), Ambrose et al. (2001).

- Require that Member States set up systems to ensure ELVs are treated within authorised treatment facilities.
- Set progressively higher re-use, recovery and recycling targets and an ultimate recovery target of 95% by weight by 2015.
- Set standards for treatment and environmental protection which authorised treatment facilities must meet.
- Encourage manufacturers to design their vehicles with recyclability in mind, as set out in Article 4 of the ELV Directive.
- Restrict the use of heavy metals in the manufacture of new vehicles.

A methodology for data collection and reporting is required to demonstrate compliance, i.e. achievement (or progress towards achievement) of targets and establishment of approved processing systems. This methodology not only needs to be robust, but also practical, verifiable and reproducible.

Vehicles subject to the provisions in the ELV Directive

ELVs are defined in accordance with the definition of ‘vehicle‘ given in the ELV Directive (Directive 2000/53/EC). This states that ‘vehicle means any vehicle designated as category M1 or N1 as defined in Annex II (A) to Directive 70/156/EEC, and three wheel motor vehicles as defined in Directive 92/61/EEC, but excluding motor tricycles’. Categories M1 and N1 are described as follows:

- Vehicles of category M1 (vehicles having at least 4 wheels, or having three wheels when the maximum weight exceeds 1 metric tonne, used for the carriage of passengers, and comprising no more than 8 seats in addition to the drivers).
- Vehicles of category N1 (vehicles having at least 4 wheels, or having three wheels when the maximum weight exceeds 1 metric tonne, used for the carriage of goods, having a maximum weight not exceeding 3.5 metric tonnes).

The body type categories used in the UK that most closely match these descriptions are ‘cars’ (defined as taxis, estate cars, three and four wheel cars, and minibuses except where otherwise stated), and ‘light goods vehicles’ (defined as those vehicles not over 3.5 tonnes maximum permissible gross vehicle weight). Light vans mainly include vehicles of the van type constructed on a car chassis). Heavy goods vehicles (HGVs), buses and motorcycles are not included within the statutory definition.

The ELV Directive states that a vehicle becomes an ELV when 'the vehicle is a waste as defined by Article 1a of Directive 75/442/EEC'. This in turn states that a waste is 'any substance or object (in the categories set out in Annex 1) which the holder discards or intends or is required to discard' (Directive 75/442/EEC amended by Directive 91/156/EEC).

The point at which a vehicle becomes an ELV has implications not only for determining the number of ELV arisings but also the facilities required to process ELVs. This is because ELVs that are intended to be discarded, but that have not yet been de-polluted, have been placed on the revised hazardous waste list. This might imply that salvage companies, and any 'co-operating organisations' who may agree to assist in the 'take back' of vehicles from last owners, would require facilities and licenses for handling special waste. It is also not clear at present if this includes all replacement parts (see Box 3.3).

Legislative arrangements for 'Non-Statutory ELVs'

Not all motor vehicles are included within the definition of end of life vehicles in the ELV Directive. This study necessarily takes account of these 'non-statutory end of life vehicles', since they are included as part of the overall definition of the UK motor industry. At present there is no statutory requirement to collect data on these vehicle types. However the collection of this data has been carried out using various sources to attempt an aggregation of the environmental impacts from these sectors of the industry. These include:

- Heavy goods vehicles.
- Buses and coaches.
- Motorcycles.

Section 8 of the Vehicles (Crime) Act 2001 allows the Secretary of State to make regulations for the notification by registered motor salvage operators of the destruction of motor vehicles which fall outside the scope of the ELV Directive (i.e. vehicles which are not cars or light vans). Section 35 of the Act amends the Scrap Metal Dealers Act 1964 and provides for a similar power in respect of scrap metal dealers. The Home Office has stated that it intends to use these powers to introduce regulations at the same time as the regulations are made under the ELV Directive. This will reduce the burdens on business by implementing a similar 'certificate of destruction' system for such vehicles, thus avoiding duplication (Home Office, 2004).

Box 3.3 Does the ELV Directive include replacement parts?

Article 3 of the ELV Directive states that the Directive covers 'vehicles and end of life vehicles including their components and materials……this shall apply irrespective of whether it is equipped with components supplied by the producer or with other components whose fitting as spare or replacement parts accords with the appropriate Community provisions or domestic provisions'.

In short, an ELV includes fitted parts that may have been added as spare or as replacement parts during the working life of the vehicle. It is not clear, however, whether an ELV includes 'additional' accessories such as roof racks, seat covers etc, and this would need to be clarified before being transposed into UK law.

It is also unclear whether an ELV includes those worn or damaged parts that have been removed from the original vehicle during its life. In essence, replacement parts reach their end-of-life prior to that of the main vehicle. As these parts will be either reused, recycled, recovered or disposed in a similar manner to an ELV (although sometimes by different processing streams), should end-of-life parts be subject to the same management regime as ELVs?

Article 5 of the Directive states that 'Member States shall take the necessary measures to ensure that economic operators set up systems for the collection of all end-of life vehicles and, as far as technically feasible, of waste used parts removed when passenger cars are repaired, …'. However, as can be seen, whether damaged and/or replaced parts are subject to the same recycling/recovery targets as ELVs is subject to interpretation.

In a previous study, the quantity of material replaced on each passenger car per annum during 2000 was estimated at 19.43kg (Kollamthodi *et al.*, 2003a). Using this estimate, the total mass of components removed from a vehicle over its useful life has been estimated at 194-272 kg, assuming a useful life of 10-14 years. Hence this mass removed during maintenance activities is significant over the lifetime of a vehicle, comprising 20-30% of the mass of a typical passenger car.

In this report, the total mass of material replaced in 2000 during maintenance activities has been quantified (see Section 7.4).

3.10 Summary of the effects of increasing legislative controls

The areas of legislation summarised illustrate that the motor industry is subject to legislation which is increasing, both in complexity of provisions and in sheer numbers of statutory instruments. There are advantages and disadvantages to the actors affected by the introduction of legislation, which are a matter for debate and are beyond the scope of this project. However, in the context of sustainable resource use, they can make a valuable contribution towards stimulating action in the area of resource efficiency.

As an example discussed in Section 3.7, it can be seen that the net effect of the introduction of Integrated Pollution Prevention and Control legislation on paints and solvents used is to stimulate activities to reduce impacts associated with harmful emissions. This may occur by:

- Avoiding harmful emissions at source by eliminating materials from manufacturing processes (e.g. avoiding using solvent-based paints).

- Substituting harmful materials for less polluting materials in manufacturing processes (e.g. switch to water-based paints).

- Reducing volumes of emissions released with potentially harmful characteristics by increasing efficiency of recovery processes (e.g. using more efficient solvent recovery to prevent releases).

An approach often used in designing out environmental problems from industrial processes is known as ‘Industrial Ecology’, which has been defined as

> *‘both the interaction of global industrial civilisation with the natural environment and the aggregate of opportunities for individual industries to transform their relationships with the natural environment. It is intended to embrace all industrial activity...; both production and consumption; and national economies at all levels of industrialisation’*
>
> (Socolow, 1994).

One component of this approach is ‘Design for Environment’, which initially concentrated on designing for disassembly and recycling. However, now this approach embodies minimising all aspects of environmental impact caused during manufacture, use and disposal of products. The reduction of impacts from paints and solvent use can be characterised as a manufacturing process which is using such approaches to reduce the impacts associated with production. The application of approaches such as ‘Design for Recycling’ is likely to increase in future as a result of more stringent legislation. This is discussed further in Chapter 8, in the context of the contribution of these approaches towards integrated product policies.

4 Resource use (products)

4.1 Introduction

This chapter describes the use of resources in the motor industry under four broad headings based on the Standard Industrial Classifications (SIC). There is a direct relationship between SIC and Products of the European Inquiry (PRODCOM) data (ONS, 2001c) which has been used as the basis for data collected under this study. An overview of some of the main methodology issues is given below and presented in Box 4.1. The complete methodology is provided in Appendix 4.

For the purpose of this study, materials are defined as those that are 'directly derived from natural raw materials'. When processed into a final form, or when different materials are combined, they are considered as products. Materials within the mass balance data framework in this report tend to have been refined and used in combination with others in products before they are turned into vehicle components. For this reason, this report uses the term 'product' to refer to material resources in the mass balance. The following definitions have been used for products in this chapter:

- *Primary products* refers to products which can be described as the basic 'building blocks' of vehicles and components. For example, this would include metal products such as steel sheets.

- *Components (secondary products)* refers to the output of combining primary products to produce parts for vehicle assembly, maintenance and the aftermarket.

- *Vehicles* refers to finished motor vehicles.

Each section describes the main uses of each product type and gives details of the consumption of those products in 2000 (unless stated otherwise). The main trends and influences considered likely to affect the demand for these products in the future are also described.

To arrive at the total quantities of products used in the motor industry in 2000, the total sales of each component identified in the definition of the motor industry have been quantified (see Section 4.4). However summing the sales of all components would overstate the mass of primary products consumed as some products incorporate other materials falling within the definition for example, lead and plastic are both utilised in vehicle batteries. To avoid this double counting it has been necessary in this section to consider what adjustments are required to account for primary products and components incorporated in other component categories. The main ONS categories used for sourcing data were:

- Sector 47 of ONS Environmental Accounts, which refers to the manufacture of motor vehicles and parts of motor vehicles.

- SIC (92) (Standard Industrial Classification) 34 in PRODCOM – manufacture of motor vehicles, trailers and semi-trailers.

These two sources are directly comparable in terms of the activities they describe.

However, using these categories alone does not capture all of the component suppliers for the motor industry. To measure their contribution, it is necessary to incorporate certain proportions of a number of other economic sectors i.e. manufacture of textiles, leather, plastics, rubber, paint, glass, metal products and metal castings.

Table 4.1 provides a breakdown of the different SIC codes which provide components for the motor industry. The column entitled '% included in Motor Industry' provides our best estimate for the contribution to the motor industry of each of these economic sectors. The data were required to ensure completeness in calculating masses in the study[15].

Tables listing the full list of products (by SIC Code) included in the motor industry definition are presented in Appendix 3.

Table 4.1 Estimated contribution of other economic sectors to the motor industry

SIC	*Economic sector*	*% included in motor industry*
17	Textiles	7%
19	Leather	<1%
24.30	Paints, varnishes, printing inks etc.	10%
25.1, 25.2	Rubber and plastic products	8%*
26	Glass and glass products	<1%
27	Casting of metal	19%
28	Metal products	3%
31	Electrical machinery	9%
32	Radio, television and communications	<<1%
35.41	Motorcycles	100%

** Data given by the British Plastic Federation.*

4.2 Summary

Table 4.2 shows the production figures for the UK motor industry in 2000. To achieve this production of vehicles and components, 4.00 Mt of primary products were

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[15] *The Advisory Group for the project were asked to comment on this, providing support to the project team by providing the benefit of their fuller understanding or indicating where superior information was available. The Advisory Group agreed with the percentages presented.*

Box 4.1 Notes on methodology

The resources data in this chapter largely came from PRODCOM referenced from the Office of National Statistics. Industry estimates of primary product consumption were collected for the year 2000 through contact with ferrous and non ferrous trade associations referenced in this chapter. A number of issues concerning the methodology adopted are highlighted here:

1 The following formula was used to calculate the total UK production of components by mass where individual component information was available:

$$kg / item = \frac{\pounds / item}{\pounds / kg}$$

Where £/item is taken from UK sales and £/kg is taken from product exports

2 The masses of components supplied for aftermarket and assembly uses were calculated using real data where available by SIC code from PRODCOM. In the case of exports and some production and import data, the masses of components supplied for aftermarket and assembly were not separately identifiable, because they were not separated in the data source. Where it was not possible to distinguish between aftermarket and assembly components, 75% of the mass was assigned to components for assembly and 25% to components for the aftermarket for each SIC category affected. For some categories, the data were suppressed and no attempt was made to estimate the mass of components supplied.

3 To calculate the mass of vehicles produced, the following mean masses for vehicles in each class were calculated from available data:

- Cars and taxis = 1,035 kg (Kollamthodi *et al.*, 2003a).
- LGVs = 1,405 kg Kollamthodi *et al.*, 2003a).
- HGVs = 6,503 kg (Manufacturer’s Specification Sheets, 2003 (various)).
- Buses and coaches = 9,440 kg (SMMT, 2000;Volvo Bus, 2003).
- Motorcycles = 205 kg (MCIA, 2003).

This was multiplied by the number of vehicles from official statistics to obtain the total mass.

4 A survey was conducted to determine the volume of fluids (excluding fuels) replaced for vehicles in each category each year, in order to estimate the mass of fluids consumed by the motor industry. To calculate the total mass of fluids replaced the density for each type of fluid was required. This was because the survey conducted gave estimates of fluid removed by volume. The values used in calculations to convert the volumes to masses were as follows:

- Engine Oil, 0.9088 kg/l (source: Kollamthodi *et al.*, 2003a).
- Radiator Oil, 0.852 kg/l (source: Addinol, 2003).
- Radiator Coolant, 1.15 kg/l (source: Gulf Oil International, 2003).
- Brake Fluid, 1.07 kg/l (Cars, LGV), 0.852 kg/l (Motorcycle) (source: Brake Fluid Dot 4, 2003).

required, plus 3.08 Mt of imported components and 0.15 Mt of ELV components sold for reuse. This gives a total material resource requirement for component and vehicle production of 7.23 Mt. In addition, 0.72 Mt of fluids were required for vehicle use activities in 2000 (excluding fuels).

Table 4.2 Production and exports of vehicles and components by the UK motor industry

	Mass (Mt)
Production of vehicles in the UK	2.13 (of which exports 1.29)
Production of components in the UK*	2.23 (of which exports 1.35)
Total UK production	4.36
Of which exports	2.64

* *Mass of components produced in the UK includes components from ELVs (0.15 Mt).*

Table 4.3 illustrates the masses of components produced, imported and exported in the UK during 2000. The net supply of components during 2000 can be calculated by subtracting the mass of exported components from the sum of the masses of components produced in the UK and imported components.

Table 4.3 Masses of components produced for aftermarket and assembly in 2000 (Mt)*

(Mt)	*Production*	*Imports*	*Exports*	*Net supply*
Assembly	1.82	2.31	1.13	3.00
Aftermarket	0.26	0.77	0.22	0.80
Total	2.08	3.08	1.35	3.80

* *The mass of components produced in the UK shown here (2.08 Mt) does not include components from ELVs sold for reuse (0.15 Mt).*

Table 4.3 illustrates two important features of component manufacture in the UK. Firstly, the export market is extremely important to the UK motor industry. Secondly, component manufacture for assembly is a far bigger market than aftermarket.

4.3 Primary products used in component and vehicle manufacture

In this section, the primary products used in component and vehicle manufacture have been evaluated. They are presented here to give an indication of the relative use of different material types in the motor industry.

The design and manufacturing of motor vehicles and their constituent parts is a necessarily complicated process. There are a number of different design criteria that vehicles must fulfil. These include, but are not restricted to:

- Meeting expectations of driving performance.
- Attaining an appropriate aesthetic standard.
- Ensuring that the pricing of the finished vehicle is consistent with market expectations.
- Providing safety to driver and passengers in case of accident.
- Allowing for innovation in reducing environmental impacts.

In addition to these, manufacturers are under pressure to reduce the weight of vehicles to help reduce fuel consumption and emissions and improve performance because of legislative demands and consumer pressure. It should therefore not be surprising that a wide range of products (and hence raw materials, from which the products are derived) are used in vehicle manufacture. Table 4.4 illustrates the average composition of a passenger car, LGV, HGV, bus and motorcycle.

Table 4.4 Average composition of different types of motor vehicles in 2000 (as percentages by weight)

Vehicle	*Car*[1]	*LGV*[2]	*Bus*[3]	*HGV*[4]	*Motor cycle**[5]
Model	*'Average car'*	*Standard delivery van 3.5 GVW*	*Volvo 8500 low entry*	*Volvo FH*	*>125cc*
Ferrous metal	68%	64%	56%	80%	48%
Non-ferrous metal	8%	12%	23%	5%	30%
Plastics	9%	9%	5%	5%	13%
Glass	3%	3%	4%	1%	0.10%
Rubber	5%	5%	5%	6%	8%
Textiles	1%	n/k	0.2%	0.5%	n/k
Fluids	2%	n/k	1%	1%	n/k
Other	4%	8%	6%	2%	n/k

* *Textiles, fluids and other materials account for 1% of the mass, but the proportions are unknown.*

n/k = Not known.

N.B. Totals may differ due to rounding.

Sources: [1]Hooper et al., (2001), [2]Bouwman et al., (1997), [3]Volvo Bus, [4]Volvo Trucks, [5]ACEM.

Ferrous metal products (steel rod, cast iron etc.) are used more often than any other product in all vehicles. Steel is utilised in nearly every part of a vehicle, including exterior body panels, engine components and to some extent interior components. Non-ferrous metals such as aluminium are used to a higher proportion in buses. Motorcycles also utilise a large amount of aluminium, because designing for lightweight construction is increasingly popular on premium sporting motorcycles. Plastics are used more often in smaller motorcycles, while scooters tend to have more plastic content than larger engined motorcycles.

The 'Other' category from Table 4.4 includes a variety of primary products. For example in buses, where there are large numbers of seats built in, wood and bitumen are included in this category. These products account for a relatively large share of the mass of vehicles.

More details of the types of primary products used are presented in Figure 4.1. This describes those products considered to form the 'building blocks' of all parts and vehicles manufactured in the UK. The total quantity of primary products used by the motor industry in the UK in 2000 is estimated to be 4 Mt.

Similarly to the composition of individual vehicles, more ferrous metal was used in vehicle production (in the UK in 2000) than any other product as a percentage by weight. However, since ferrous metal has a higher density than many of the other products, caution must be exercised when interpreting these figures. For example, plastics may be used widely in vehicle components and this would be large in terms of volume, but their low density means that they account for only a 10% share of the mass.

Plastics and polymers are the second highest utilised product accounting for approximately 750 kt. This is mainly due to the pressure to use more lightweight components in vehicle manufacture. However, there are problems with recovering plastic components from the ELV waste stream in the UK at the moment. This is due to a lack of infrastructure for recovery at the end of life, but is also due to a lack of consideration of the disassembly and recycling requirements during past component design processes. However, this is changing and Box 4.2 describes an example of the motor industry's increasing commitment to consider such issues at the vehicle design stage.

The considerable increase in the use of lightweight products has also included the more widespread use of aluminium for vehicle production over the last decade. In terms of future trends, the Partnership for a New Generation of Vehicles (PNGV) proposes that there will be a growth in the use of primary casting alloys in the future (by 451% between 1999-2010, Das *et al.*, 1999). Despite this push towards the use of aluminium, most vehicle manufacturers insist that in the future no single product will dominate in vehicles (Audi, BMW, Jaguar, Volvo & Nissan, *pers. comm., 2003*). Box 4.3 illustrates lightweight design trends in more detail.

4.4 Components (secondary products)

3.80 Mt of components were supplied to the UK motor industry in 2000. This does not include data which is inaccessible for commercial reasons. For example, no data sources were recorded for sparking plugs. The limitations of the data should be considered when using these figures. Details of specific data included can be found in Appendices 3 and 4. It is worth noting that data sources reported here are limited to the information collected by ONS as part of PRODCOM and for this reason references are clearly identifiable.

Components are produced for use in vehicle assembly and for aftermarket use (vehicle maintenance, accessories and customisation). In 2000, there were approximately 7,000 component manufacturers operating in the UK, 90% of which were SMEs (Invest UK, 2003). This section summarises the mass of components produced and consumed in the UK.

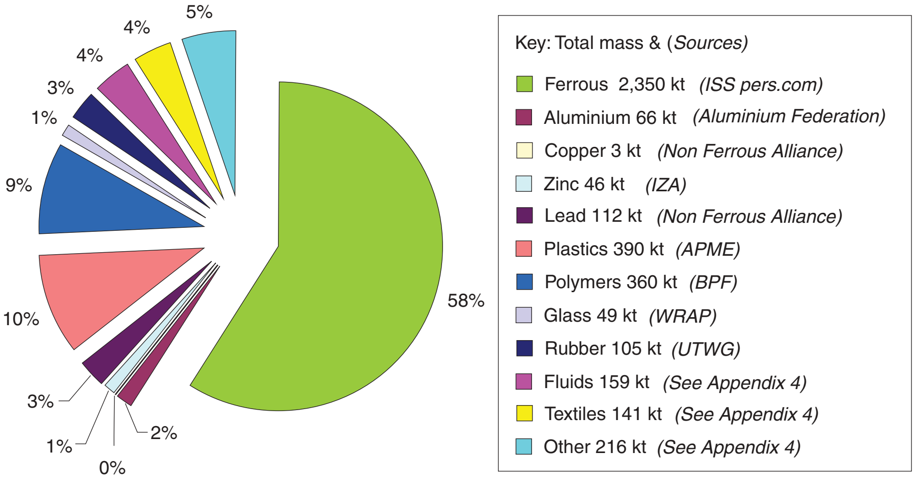


Figure 4.1 Distribution of primary products reported as used in the UK motor industry in 2000 (as percentage by weight)

Box 4.2 Plastics used in automotive design

The Ford Model U Concept follows the traditions of the Model T by being designed to be a mass produced vehicle and addressing social issues, in this case reducing environmental impacts in material choice and design. In accordance with the design principles embodied in ‘Design for Environment’ approaches to production (Graedel and Allenby, 1998), two key features are important:

- Choosing materials wisely to reduce the environmental impacts over the life of the vehicle, that is those associated with manufacture, use and disposal.

- Reducing the number and complexity of materials used so that the opportunity to recycle is maximised.

The objective in designing the Model U is to encourage development of materials that are safe to produce, use, and recycle over and over again (known as ‘cradle-to-cradle’ recycling). These materials never become waste, but instead can be continually reused in high value applications. This contrasts with many traditional recycling scenarios where the recyclate is gradually used in progressively lower value applications. Maintaining high value uses has the potential to ensure that demand for the recyclate remains high and will either maintain or expand its existing market.

An array of green materials and processes make the Ford Model U environmentally innovative in comparison with other motor vehicles. ‘Eco-effective polyester’ is the fabric designed by Milliken and Co., which can be recycled into base elements and reprocessed into material fibre again and again without losing any performance qualities. This polyester is used inside the Model U on its seats, dash, steering wheel, headrests, door trim, and armrests.

The Model U also uses a potential ‘biological nutrient’ made to safely return to the soil to feed the next generation of resource growth called polylactide (PLA), a biopolymer from Cargill Dow derived from corn. PLA fabrics, derived from Interface, are used for the Model U’s canvas roof and carpet mats. The fabric has the comfort and feel of natural fibres while having the performance and easy care of petroleum-based synthetic materials.

Renewable, plant-based components are used in several cases to replace petroleum-based materials, where it is not possible to design ‘cradle to cradle’ materials for this purpose. For example, rubber tyres use corn-based fillers as a partial substitute for carbon black. They offer lower rolling resistance and lower weight, leading to improved fuel economy and improved traction on wet pavement. In conjunction with Model U, the team from the Ford Research and Advanced Engineering is working with Shell Global Solutions to test a bio-based lubricant from sunflower seeds.

The Model U also begins to address manufacturing issues trying to develop flexible manufacturing processes that reduce energy use and parts complexity, as well as develop technical processes that have a positive environmental impact. This could also allow many different vehicles to be built in a single assembly plant with reduced inventory and lower tooling cost. This modular approach is also observed in the interior of the Model U. The armrests on all four doors are exactly the same, as are the centre armrests in the front and rear seating rows. This approach allows the recovery of the cradle-to-cradle materials as Model U is dismantled, ensuring the continuing use and recycling of these materials in high value uses.

Sources: Ford Motor Company, 2003; Graedel and Allenby, 1998.

Box 4.3 Lightweight design trends

Recent advances in vehicle body construction technology have led to the introduction of small numbers of mass-produced vehicles with light-weight aluminium bodyshells. Widespread use of aluminium body panels can lead to significant reductions in overall vehicle weight. To date, Audi is the only passenger car manufacturer selling volume-produced cars with bodyshells made from aluminium. A comparison of the differences between equivalent aluminium and steel-bodied passenger cars is given in the following table.

Model	*Bodyshell construction*	*Length*	*Mass*	*% change in mass*
Mercedes-Benz A140	Steel monocoque	3575 mm	1020 kg	–
Audi A2 1.4	Aluminium space frame	3825 mm	895 kg	-12.25
Mercedes-Benz S280	Steel monocoque	5038 mm	1695 kg	–
Audi A8 2.8 V6	Aluminium space frame	5035 mm	1540 kg	-9.14

Source: Manufacturers specification sheets.

This equates to a mass saving of approximately 10% in switching to an aluminium frame. It is of interest to many researchers how this potential could be used to introduce a number of design benefits, including better fuel consumption and reduced emissions in use without decreasing vehicle performance. Whether such benefits are realised is a moot point, since design trends (such as increasing vehicle size and increasing the number of electrical goods supplied as standard) indicate that the mass of vehicles will continue to increase in future.

Overall, the UK produced 2.08 Mt of components in 2000 (including 0.15Mt of ELV components sold for reuse), 1.35 Mt of which were exported, whilst 3.08 Mt were imported for vehicle assembly and for aftermarket use (see Table 4.3). The high mass of imports could be attributed to the fact that return on capital for the UK component industry has been very low causing companies to make losses (Automotive Innovations Growth Team, 2002) and possibly moving these industries out of the UK.

Electrical lighting and visual signalling equipment contained in the interior category had the largest discrepancy between imports and exports. In 2000, 126 t of these components were exported, compared to over 700,000 t imported. Figure 4.2 categorises the mass of components produced in the UK Motor industry in 2000.

For the purposes of summing the data, vehicle engineering categories were used to group the vehicle components. The category with the highest mass, the powertrain, refers to parts associated with the engine and vehicle transmission containing, but not restricted to the axles, drive shaft, clutch and gear box.

4.5 Vehicle manufacture

Table 4.5 and Table 4.6 present figures for all vehicles produced in terms of volume and mass. The figures for the total vehicles exported and imported are also presented.

In total, 2.13 Mt of vehicles were produced in the UK in 2000. 2.1 Mt of vehicles were imported into the UK and 1.29 Mt were exported.

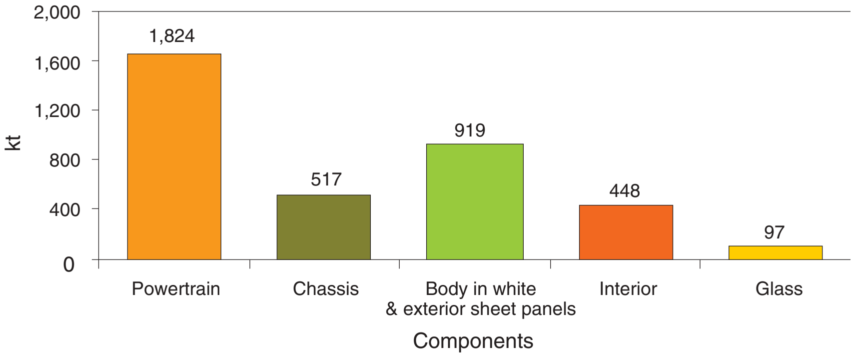


Figure 4.2 Net supply of components supplied in the UK motor industry in 2000 (kt)

Table 4.5 Vehicle production, imports and exports in 2000 (Millions of vehicles)

Type of vehicle	*Number produced*	*Number imported*	*Number produced for export*	*Addition to stock (as number of vehicles)*
Cars and taxis	1.64	1.62	1.06	2.20
Light goods vehicles	0.15	0.14	0.07	0.22
Heavy goods vehicles	0.02	0.03	0.01	0.04
Buses, coaches and minibuses	0.01	0.00	0.01	0.01
Motorcycles	0.18	0.22	0.03	0.37
Totals	2.00	2.01	1.17	2.83

Sources: [1]SMMT (2003d); [2]Office of National Statistics (2002); [3]Volvo Buses (2003), [4]Bus and Coach Magazine (2003), [5]Motor Cycle Industry Association (2003).

Table 4.6 Vehicle production, imports and exports in 2000 (by mass)

Type of vehicle	*Mass produced (Mt)*	*Mass imported (Mt)*	*Mass produced for export (Mt)*	*Addition to stock (Mt)*
Cars and taxis	1.70	1.68	1.10	2.28
Light goods vehicles	0.20	0.19	0.09	0.30
Heavy goods vehicles	0.09	0.19	0.04	0.25
Buses and coaches	0.11	0.01	0.06	0.06
Motorcycles	0.03	0.03	0.01	0.05
Totals	2.13	2.10	1.29	2.94

Sources: SMMT (2003d); DETR (2001a); Volvo Bus (2003), Bus and Coach Magazine (2003), Motor Cycle Industry Association (2003).

For all vehicle classes, the number of vehicles added to stock is positive, indicating that the sum of vehicles produced and imported is larger than the number of exports for 2000. This is especially the case for passenger cars, which make up 78% of the additions to stock during 2000.

There were similar masses of vehicles imported and produced in the UK in 2000 (both 2.1Mt). The large mass of car imports in comparison with exports suggests that the majority of car assembly activities for cars sold in the UK take place outside the UK.

For all vehicle classes many more vehicles are imported than exported. The only exception to this is buses and coaches, where the mass of imports is low. This is due to a comparatively large proportion of supply being met in the UK.

In order to increase the level of confidence within the vehicle production figures and show any identifiable trends, UK production figures were examined against new registrations. Figure 4.3 illustrates the number of vehicles produced and registered per annum over a five year period for both passenger cars and commercial vehicles (CV) including light goods vehicles, heavy goods vehicles and buses in the UK.

Figure 4.3 puts the number of vehicles produced at 1.81 million and the number of new registrations at 2.52 million. Table 4.5 has quantified the numbers of vehicles added to stock (as net vehicle imports) during 2000 as 2.83 million. The greater number of vehicles quoted in this study is due to the inclusion of some vehicle classes not included in the SMMT figures.

Figure 4.3 demonstrates that commercial vehicle production is almost identical to new registrations and this has remained steady over the last 5 years. By contrast, passenger car production falls below the number of cars registered in the UK each year. This implies that a considerable proportion of vehicles in use are assembled and manufactured abroad each year, supporting the observations made regarding the data for passenger cars in Tables 4.5 and 4.6.

In total, Table 4.6 illustrates that 2.13 Mt of vehicles by mass were manufactured in 2000 in the UK.

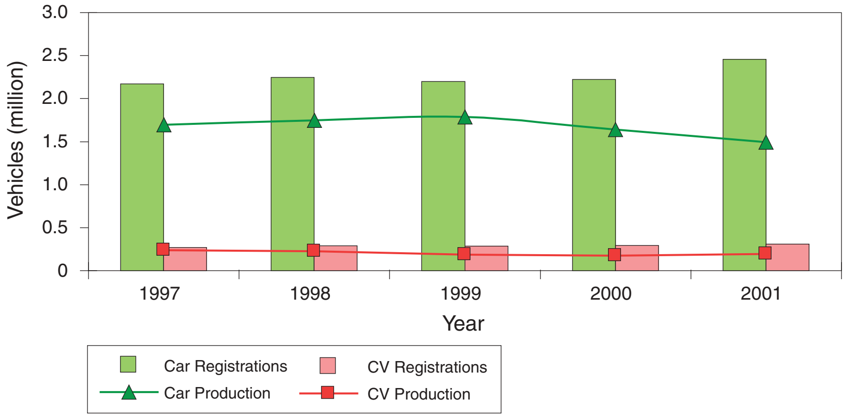


Figure 4.3 UK new vehicle registrations and production over five years

4.6 Vehicle maintenance during use

As part of the analysis of the masses of component products, this study has shown that the UK produced 0.26 Mt of aftermarket products in 2000 (see Table 4.3), and imported and exported 0.77 Mt and 0.22 Mt respectively. This is a net supply of 0.81 Mt. This includes all new components produced and imported into the UK during 2000, but it does not include:

- Those components held in stores.
- Figures not available from ONS because of commercially sensitivity.

It has been assumed for the purposes of the mass balance methodology, that:

- The number of new components consumed in maintenance is equal to the number of waste components arising.
- The ONS figures derived for components imported, produced and exported for aftermarket applications include all parts used for vehicle maintenance.

For this reason a separate study was conducted to examine the types of components replaced over a yearly period and the proportion of the total aftermarket production this accounted for. This is reported in the chapter of this report dealing with waste arisings (Chapter 7).

The total parts supplied for replacement in 2000 was estimated as 1.12 Mt on the basis of the study (including 0.15 Mt of components sourced from ELVs and sold for reuse). However, the aftermarket includes components used for modifying the appearance of vehicles and accessories, as well as the replacement parts which were quantified in the study. It was not possible to quantify the components used for modifications and accessories due to a lack of good data. For this reason, the figure quoted will be an underestimate, since it includes only replacement parts.

4.7 Discussion

This chapter has shown that the use of products is influenced by a range of complex issues relating to supplying primary products, assembling vehicles and supplying component parts.

In particular, the high mass of motor component and vehicle imports is attributed to fundamental transformations that are taking place currently in the UK. Several of the major car manufacturers approached stated that they intend to greatly increase their future supplies of components and assemblies from countries in Europe and the Far East where production costs are lower. As a result, aftermarket parts markets have been in decline, although components supplied for assembly is expected to increase because of high production targets set by UK vehicle manufacturers (Research and Markets, 2002)

In terms of having strategic control over encouraging more sustainable resource use in the UK, this has some implications. Since countries with lower production costs may have less control systems in place to control environment impacts, the industry would need to have safeguards in place to ensure that the same degree of control was exercised as one would expect in the UK. For component imports, it is likely that supply chain pressures would ensure that vehicle manufacturers would be able to demand that these measures should be put in place by their suppliers.

A large proportion of new vehicle registrations are imported primarily from other European countries, Japan and USA and overall vehicle production in the UK has declined. In particular, there are more vans manufactured in the UK than heavyweight trucks but both outputs are small when compared to manufacturing in Europe. Ultimately, the burden for the use of materials and energy and emissions produced to supply cars for the UK market falls on other countries, while the burden of dealing with waste arisings when the cars reach the end of life is borne by the UK. This demonstrates the lack of international boundaries in dealing with the impacts from domestic use of products. It follows that any policies to encourage more sustainable resource use would need to address an internationally agreed agenda, rather than focussing too narrowly on domestic interests. For this reason, it is likely that there will continue to be a reliance on voluntary agreements as an important means of implementation.

Evidence suggests that the material composition of a vehicle has changed considerably over the last decade and it is likely to continue to change. With vehicle manufacturers continually looking at ways to reduce the weight of their vehicles, lighter materials such as aluminium and plastics are replacing components traditionally made from heavier ferrous materials. The reduction in overall vehicle weight reduces the overall emissions produced from a vehicle. However, if vehicle sizes continue to increase in future, then it follows that more resources will be required for manufacturing vehicles. In this scenario the benefits from using lightweight materials may not be realised.

At present, it is not clear to what extent the pursuit of the ELV Directive requirements to achieve the recycling of 95% of a vehicle by weight by 2015 will affect the trend for using lighter materials in vehicle production. Steel can be recycled more easily than plastic and also weighs much more, so in terms of percentage by weight this boosts the recyclability of the vehicle. This suggests that in policy terms, there may be trade-offs to consider between the desirability of making vehicles more recyclable against the energy and emissions reductions associated with lighter vehicles. For example, the plastic body panels used by Renault in the Espace have now been replaced with steel panels.

Attention will also need to be paid to ensuring that materials are chosen wisely and that components are designed intelligently, so that the total life cycle impacts of products may be reduced. Policy approaches to encouraging the further proliferation of 'Design for Environment' approaches in the motor industry are discussed fully in Chapter 8.

5 Energy use

5.1 Introduction

This chapter presents data on the amount of energy used by the motor industry in 2000. Calculations for this section were based on data presented in the DTI's Digest of Energy Statistics (2003 and 2001 editions), ONS statistics, and NETCEN data. Data for the whole of the UK were apportioned to the motor industry on the basis of economic data, for production of vehicles and first tier component manufacturers. For the transport phase, data were readily available from ONS and NETCEN as fuel consumed by each type of vehicle. The transport of materials and goods within the UK motor industry, including for maintenance activity, is part of the use phase and therefore it has not been analysed separately, thus avoiding double counting. Further methodological issues are set out in Box 5.1.

The energy uses quantified in this section relate to:

- The manufacture of motor vehicles in the UK.
- The manufacture of replacement parts in the UK.
- The use of UK-manufactured and imported motor vehicles in the UK.

It has not been possible to quantify the energy used in the following activities, and consequently they have been omitted from the study:

- Vehicle maintenance.
- Energy used for processing ELVs.

However, these two activities are believed to be insignificant in comparison with the other energy uses quantified.

Box 5.1 Note on methodology

The energy data used in this section largely came from the ONS Environmental Accounts data (ONS, 2003) and from the ONS/DTI Digest of Energy Statistics (2003 and 2001 edition) for comparisons with the national data. A number of issues concerning the methodology adopted are highlighted here:

1. Figures for fuel use by product and material manufacture were calculated by apportioning ONS statistics for energy use with industry manufacturing sales statistics. It is acknowledged that this is not an ideal method to calculate energy consumption. Issues associated with this approach include:

    - The methodology assumes that energy consumption is consistent across all industries.
    - Not all products are traded.
    - The sales data were not complete.

    Notwithstanding the above, this was found to be the most practical method to adopt given the data available.

    ONS energy use data were used, since the data from the DTI were not available to determine the energy consumption within industry sectors examined at the level of SIC code. The DTI acknowledge in their Digest of Energy Statistics publication that ‘the consistency of the classification across different commodities cannot be guaranteed because the figures reported are dependent on what the data suppliers can provide’ (DTI, 2001). ONS data, on the other hand, are sourced from the NETCEN background work for the production of emissions data (NETCEN, 2003). A slight difference in the consumption by the road transport sector (about 2Mtoe) between the DTI and the NETCEN data can be observed when comparing the total figures given in Table 5.1 and Table 5.2.

2. The energy figures presented for product and material manufacture do not include any energy used in the processing of reused/recycled/reclaimed materials.

3. Figures on fuel consumption by transport were sourced from the NETCEN data used as basis for the emissions calculations (NETCEN, 2003) as the DTI data are not available at the same level of details (energy consumption per type of fuel and type of vehicle). Further details are given in Appendices 2, 3 and 4.

5.2 Summary

Energy use in the motor industry in 2000 was 41.37 million tonnes of oil equivalent (Mtoe), representing a quarter of the total amount of energy consumption in the whole of the UK for the year (171.23 Mtoe). A summary of energy use by the motor industry is given in Table 5.1 and Figure 5.1. Table 5.2 illustrates the amount of energy consumed by the motor industry as compared with all UK industry and total consumption of energy by all sources. Figure 5.2 illustrates energy use by vehicle type.

Table 5.1 Energy use in the motor industry (toe)

Fuel type (toe)	*Vehicle and component production*	*Vehicle use*	*Total UK consumption*
Natural gas	812,165	–	–
Coal	53,737	–	–
Petrol	8,769	23,319,099	–
DERV	36,754	16,593,345	–
Fuel oil	18,858	–	–
Gas oil	126,780	–	–
Net electricity	397,404	–	–
Total	1,454,467	39,912,444	171,233,000

Source: NETCEN (2003b)

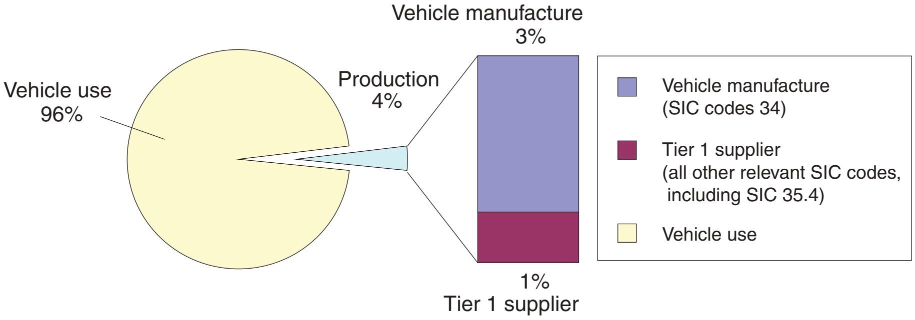


Figure 5.1 Energy use in the motor industry in 2000 by activity

Table 5.2 Comparison of energy consumption by the motor industry with 1) UK industry as a whole and 2) All UK energy consumption in 2000

Fuel type (toe)	*Motor industry (production only)*	*UK industry*	*Vehicle use*	*National consumption*
Petroleum products	191,161	6,077,000	39,912,444	77,727,000
Coal	53,737	485,000	–	2,010,000
Natural gas	812,165	15,773,000	–	58,261,000
Electricity	397,404	9,812,000	–	28,325,000
Total	1,454,467	32,147,000	39,912,444	166,323,000*

Source: DTI (2003b), NETCEN (2003b).
** This total differs from that given in Table 5.1 due to different data sources (see Box 5.1).*

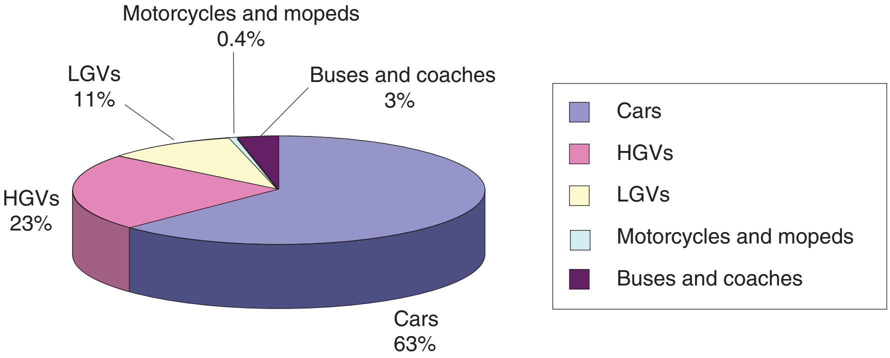


Figure 5.2 Energy use by vehicle type in 2000

In 2000, the production activities of the motor industry accounted for 5.3% of UK GDP, generating a total of £45 billion of annual sales. This involved using 4.5% of the total energy consumption for the whole of the UK's production industry (1.45 Mtoe against the industry total consumption of 32.15 Mtoe). As a proportion of the total consumption of energy in the UK, this equates to only 0.9% of the 171.20 Mtoe UK total excluding power generation (NETCEN, 2003b).

Vehicle use (road transport) is the main user of energy in the UK motor industry, consuming 39.91 Mtoe in 2000. As a proportion of UK consumption, this is 23.3% of the total consumption in 2000. This is significant and suggests that reducing the energy used by vehicles during use will remain a priority.

5.3 Manufacture of parts and vehicles

Energy used in production is small in comparison with that used in transport (see Section 5.4). As a whole, these activities account for only 4.5% of the energy used by the motor industry in 2000, of which 78% was used in vehicle manufacturing activities (defined as SIC 34 activities).

Table 5.3 presents the data obtained for energy used in production, showing the proportions of each energy source supplied. Table 5.4 presents a more comprehensive breakdown of the figures for each SIC activity in the study.

Table 5.3 Energy use in production by source in 2000

Energy source (toe)	*Vehicle manufacture (SIC codes 34)*	*Tier 1 supplier (all other SIC codes, including SIC35.4)*	*Total production*
Natural gas	641,350	170,814	812,165
Coal	44,366	9,371	53,737
Petrol	8,065	704	8,769
DERV	32,446	4,307	36,754
Fuel oil	8,983	9,875	18,858
Gas oil	111,025	15,756	126,780
Net electricity	293,850	103,554	397,404
Total	1,140,085	314,382	1,454,467

Sources: DTI (2003b), ONS (2003), NETCEN (2003a).

Table 5.4 Summary of energy consumption by the motor industry in kilotonnes of oil equivalent (ktoe)

Ref	*Activity*	*Motor spirit*	*DERV*	*Gas oil*	*Fuel oil*	*Coal*	*Natural gas*	*Net electricity*	*Total*
1	Use phase: road transport	23,319.10	16,593.35	–	–	–	–	–	39,912.44
2	Production phase: SIC code 34 (Motor industry: production of vehicles and parts)	8.06	32.45	111.02	8.98	44.37	641.35	293.85	1,140.09
3	Production phase: SIC code 35.4 (Motorcycles)	0.00	0.01	0.03	0.03	0.00	1.21	0.50	1.78
4	Production phase: SIC code 17.5 (Textiles)	0.11	0.92	2.50	5.63	2.48	47.75	18.34	77.73
5	Production phase: SIC code 25.1 (Rubber and rubber products)	0.12	0.69	2.68	1.47	6.66	20.51	12.19	44.32
6	Production phase: SIC code 25.2 (Plastic and plastic products)	0.10	0.41	2.18	0.26	0.00	5.68	6.83	15.46
7	Production phase: SIC code 26.1 (Glass)	0.03	0.19	0.77	0.18	0.00	4.16	1.23	6.55
8	Production phase: SIC code 27.5 (Casting of metals)	0.11	0.47	2.54	0.42	0.00	51.79	30.42	85.75
9	Production phase: SIC code 28.4 (Fabricated metal products)	0.15	0.86	3.36	0.79	0.01	20.31	14.55	40.03
10	Production phase: SIC code 31.6 (Electrical equipment)	0.08	0.76	1.70	1.10	0.22	19.40	19.49	42.74
11	Production phase: SIC code 32.3 (Radio)	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Total		23,327.87	16,630.10	126.78	18.86	53.74	812.16	397.40	41,366.91

Source: DTI, 2003b.

5.4 Vehicle use

The use phase of the industry (road transport) accounts for the largest share of the energy use in the motor industry. In fact, road transport accounts for nearly a quarter of the whole UK consumption of energy. The share of energy use attributed to transport generally (including aviation and other transport modes) has increased in recent years as 'heavy' industries, which have traditionally been regarded as energy intensive, have declined (see Box 5.2).

Table 5.5 Split in use of fuel by vehicles (Mtoe)

Vehicles	*Petrol*	*DERV*	*Total*	*Percent -age of total*
Cars and taxis	22,118	2,962	25,080	63
HGVs	_	9,170	9,170	23
LGVs	1,033	3,171	4,204	11
Motorcycles and mopeds	168	_	168	<<1
Buses and coaches	_	1,291	1,291	3
Total	23,319	16,593	39,912	100

Source: NETCEN (2003b).

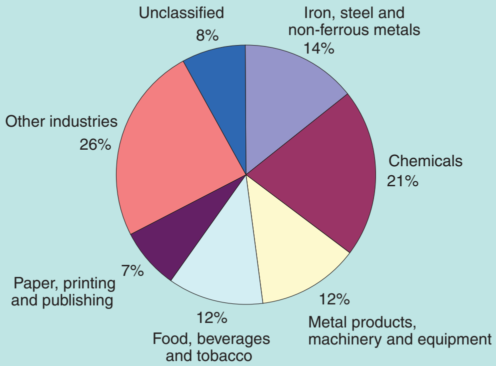
Passenger cars account for about 63% of the energy used in road transport. The use of cars for personal travel has been rising in the last few years, especially for short trips. An analysis of travelling habits in the UK is shown in Box 5.3.

LGVs and HGVs together account for 34% of energy use. Therefore, although a switch to using alternatives for transporting freight would reduce this figure and would have significant benefits in its own right, it will have a comparatively small effect unless the increasing passenger car use in the UK is also addressed.

Box 5.2 Trends in energy consumption in the UK

In 1970 industrial activities (including iron and steel manufacture) was the sector with the greatest level of consumption, which accounted for 43% of total UK consumption. However, since 1970 this sector has steadily reduced its consumption to 23% of the total, mainly due to an overall change in the types of industrial activity in the UK, but also due to improved energy efficiency practices. Focusing on the industrial consumption of energy, which amounted to about 32 Mtoe in 2000 (DTI, 2003), iron and steel industries consume 14% of the total, while the chemical industry uses about 21%. The switch away from 'heavy' to 'light' industrial activities explains the decrease in energy intensity (i.e. the ratio between energy consumed and output) between 1990 and 2002. Energy intensity fell by approximately 15% over this period.

Industrial consumption: share amongst industries



The proportion of energy consumed by the industrial sector is now less than that of the domestic sector in the UK. The domestic sector has continued to use a similar percentage of the total UK energy use since 1985 (29%). The area showing the greatest increase in energy use since 1970 has been in the transport sector. The proportion of total UK energy used by the transport sector has risen from 19% in 1970 to 34% in 2000.

Source: DTI, 2003b

5.5 Discussion

The use of motor vehicles has the greatest energy consumption of all the motor industry activities evaluated for 2000, equal to approximately 40 Mtoe. This alone exceeded the whole UK industry consumption and contributed nearly a quarter of the overall UK consumption. Energy use in the road transport sector has increased by about 7% since 1990, while UK industry as a whole used 10% less energy in 2000 (DTI, 2001). This reflects the changes in the UK industrial sector, which has seen the decline of 'heavy' manufacturing such as steel production, and an increase in 'light' industrial activities. At the same time, UK industry has embraced energy saving measures, such as switching to different fuels and improved efficiency. This has also been the case in the motor manufacturing industry, where, for example, a new car coming on to the market in 2000 achieved a fuel economy of 39.9 miles per gallon, which compares with 36.9 in 1990 (SMMT, 2003c). It was estimated that this figure would rise to 40.9 miles per gallon in 2002.

Unfortunately, energy efficiency improvements in new vehicles have been countered by the increase in distances travelled and switching from public transport to cars since

Box 5.3 Personal travel in the UK

The average person travelled 6,843 miles per year in 1998-2000 in Great Britain, including a distance of 1,350 miles travelled through commuting to work. 80% of the total distance travelled was by car, while public transport accounted for only 12.5%. Travel by public transport fell by 5% between 1990 and 2000 whilst walking and cycling declined by 17%.

The average length of a car trip in 1999/2001 was 8.7 miles, which represents an increase of 6% from 1989/91 when the average was 8.2 miles. Cars were used for 18% of trips under 1 mile and for 61% of trips of between 1 and 2 miles. For trips of less than 25 miles, the proportion of trips made by car rose with journey length, reaching 87% for trips of between 10 and 25 miles. For trips of 25 miles and over, the proportion made by car was 86% for trips of between 25 and under 50 miles, and 78% for trips over 100 miles in length.

Another significant indicator is the car occupancy level. Since 1985-86, average car occupancy has fallen from 1.63 to 1.56. Overall 64% of people making a car trip were the driver, as opposed to a passenger. For commuting, this increased to 83% of those travelling by car. Average vehicle occupancy levels only rise above two on education and holiday/day trips.

The British Social Attitudes Survey, which explored people's attitudes to car use in 1999, found that around three out of ten adults in Great Britain agreed that many of the short journeys they made by car could just as easily have been done by bus. Around four in ten agreed that they could walk instead of travelling by car. The survey also explored attitudes to measures which were intended to change their car usage. Over half of respondents with regular use of a car thought they might use cars a little or quite a bit less, or give up using the car, for each of the following reasons:

- Gradually doubling the cost of petrol over the next ten years.
- Greatly improving the reliability of public transport.
- Greatly improving long-distance rail and coach services.
- Charging all motorists around £2 each time they enter or drive through a city or town centre at peak times.
- Cutting in half long-distance rail and coach fares or local public transport fares.

Sources: ONS, 2001a; DfT, 2003b.

1990 (see Box 5.3). However, the energy intensity of freight transport on road has been largely constant since 1990, notwithstanding the move towards larger trucks that consume more energy.

The Government and the motor industry are actively addressing this paradoxical problem together, not least because of the associated problems with increasing air emissions from road transport (see Chapter 6). For example, some policy measures employed include encouraging vehicle manufacturers to produce more efficient (and less polluting) cars and encouraging users of transport to select alternatives to road transport where possible. A variety of means are available to effect such changes, including differential taxation of vehicles, congestion charging and improvement of public transport. More discussion of the available policy options is presented in Chapter 8.

6 Emissions to air

6.1 Introduction

This section presents data on emissions to air for activities carried out by the motor industry in 2000. The data were obtained from the Office for National Statistics/DEFRA (ONS/DEFRA, 2003) and their source, the National Air Emissions Inventory (NETCEN, 2003a, NETCEN, 2003b). Further detail on the methodology adopted is given in Box 6.1 and in Appendix 4.

The emissions to air quantified in this section relate to:

- The manufacture of motor vehicles in the UK.
- The manufacture of replacement parts in the UK.
- The use of UK-manufactured and imported motor vehicles in the UK.

It has not been possible to quantify the air emissions produced by the following activities, and consequently they have been omitted from the study:

- Vehicle maintenance.
- Processing ELVs.

However, the air emissions from these two activities are believed to be insignificant in comparison with the other sources quantified in this report.

To ensure that the inputs and outputs of emissions for vehicles in use were balanced, it was necessary to calculate oxygen consumption and water vapour production from carbon: hydrogen ratios in fuel combustion. The data used for the calculations are presented in Appendix 2 and the methodology discussed in Appendix 4. The emissions reported relate to direct

Box 6.1 Methodology

The data used for calculating the air emission figures were mainly sourced from the Digest of Environmental Accounts, published by DEFRA and produced by the ONS (DEFRA/ONS, 2003) and related spreadsheets (ONS, 2003a). The data relating to air quality are sourced from the National Environmental Technology Centre (NETCEN), the organisation responsible for the reporting of the UK emissions to the United Nation Framework Convention on Climate Change (UNFCCC). The ‘UK National Emissions Inventory 2003’ (NETCEN, 2003a) has been used in this report for the transport and the total UK emissions contributions of the main gases (see Appendix 4). The data from the DEFRA/ONS publications are categorised by industrial activity, which can be directly compared to SIC codes for motor industry activities used to define the UK motor industry in this report. Full details of the methodology are given in Appendix 4. Figures for emissions resulting from product and material manufacture were calculated by apportioning ONS data according to industry manufacturing sales statistics. It is acknowledged that this is not an ideal method to calculate emissions to air. Issues associated with this methodology include:

- Products that have been excluded from the definition of the motor industry to avoid double counting still produce emissions in their manufacture: those emissions have therefore been excluded.
- The methodology assumes that emission generation is consistent across all industries.
- Methodology assumes that value is proportional to emissions generated.
- Not all products are traded.
- The sales data were not complete.

The emissions reported relate to direct emissions only and as such do not include any emissions resulting from National Grid energy usage. As the use phase of the motor industry already includes all the transport of goods and materials, the transport of finished vehicles and their components has not been separately identified to avoid double counting. Road transport emissions are subject to continuous monitoring and study as part of the UK Government’s efforts to improve air quality. The NETCEN National Air Emissions Inventory data has been used to identify emissions due to each vehicle class included in the study. This data source is updated annually. In addition to all of these parameters, it was also necessary to calculate the oxygen consumption and water vapour generation during combustion of fuels during vehicle use, which is also a source of carbon emissions. This was required to complete the mass balance for energy use and emissions and was calculated from fuel combustion equations using carbon and hydrogen ratios. It was not possible to calculate these figures for the motor manufacturing mass balance. These emissions are not discussed further in this chapter. Further details on the data and calculations are given in Appendices 2, 3 and 4.

emissions only and as such do not include any emissions resulting from National Grid energy usage. For this reason, and because of the omission of ELV processing emissions, the figures presented underestimate the motor industry emissions.

In order to provide a meaningful interpretation of the consequences of the emissions, it is usual to describe the effects associated with emissions quantified. In this study, all the available data have been classified into four categories of emissions. Table 6.1 shows the how the gases quantified in this study have been classified by their environmental effects. It should be noted that a number of these emissions have multiple effects and where possible they have been listed. For example, carbon monoxide is involved in reactions leading to the creation of photochemical smog, but is also a toxic pollutant. A full description of the terms used is given in the glossary.

Table 6.1 Broad categorisation of air emissions quantified in the study

Nature of effects	*Air emissions quantified*
Greenhouse gases (global warming)	Carbon Dioxide (CO_2) Methane (CH_4) Nitrous Oxide (N_2O) Hydrofluorocarbons (HFC) Perfluorocarbons (PFC) Sulphur Hexafluoride (SF_6)
Acid gases (acidification)	Nitrogen Oxides (NO_x) Sulphur Oxides (SO_x) Ammonia (NH_3) Hydrogen Chloride (HCl) Hydrogen Fluoride (HF)
Pollutants with potential to cause smog (photochemical oxidant creation)	Nitrogen Oxides (NO_x) Non Methane Volatile Organic Compounds (NMVOC) Carbon Monoxide (CO) Low Level Ozone (O_3)*
Toxic pollutant (Human toxicity	Arsenic (As) Chromium (Cr) Copper (Cu) Mercury (Hg) Nickel (Ni) Lead (Pb) Selenium (Se) Vanadium (V) Zinc (Zn) Persistent Organic Pollutants (POPs)[†] Particulates (PM_{10}) Black Smoke Benzene (C_6H_6) 1,3-Butadiene (C_4H_6) Carbon Monoxide (CO)

* *Formed by chain reactions between the other air emissions, so not strictly speaking an emission from the motor industry.*

[†] *Includes Polychlorinated Biphenyls (PCBs), Dioxins (PCDDs), Furans (PCDFs), Polycyclic Aromatic Hydrocarbons (PAHs).*

Source: ONS/DEFRA 2003.

In addition to simple quantification, selected emissions were examined based on the World Business Council for Sustainable Development (WBCSD) 'eco-efficiency' indicators (Verfaillie and Bidwell, 2000). The objective here was to describe gaseous emissions which contribute to:

- Global warming (more commonly known as 'greenhouse gases') in terms of CO_2 equivalents.
- Acidification potential for acid gases (with effects such as 'acid rain') in terms of SO_2 equivalents.

The former has been described as one of a set of 'generally applicable' indicators of eco-efficiency by WBCSD, whereas the latter is listed as an 'additional indicator'. This is because there is not yet general agreement on how to measure acidification, but once this is established it will have the same status in the opinion of WBCSD as the global warming indicator. Acidification potential has been evaluated in this study because motor vehicles in use were known to contribute greatly towards acid gas emissions[16].

The emissions examined in this study are listed in Table 6.2 (together with their CO_2 equivalents) and Table 6.3 (together with their SO_2 equivalents).

Table 6.2 CO_2 equivalents used to calculate the global warming potential for greenhouse gases in this study

Emissions quantified	*CO_2 equivalent*
CO_2 (Carbon Dioxide)	1
CH_4 (Methane)	21
N_2O (Nitrous Oxide)	310
HFCs (Hydrofluorocarbons)*	Average of 6000 adopted
PFCs (Perfluorocarbons)*	
SF_6 (Sulphur hexafluoride)*	

* *Follows convention adopted in previous mass balance study by Smith et al., 2002.*

Source: Houghton et al., 1996

Table 6.3 SO_2 equivalents used to calculate the acidification potential for acid gases in this study

Emissions quantified	*SO_2 equivalent*
SO_2 (Sulphur Dioxide)	1
NO_x (Nitrogen Oxides)	0.7
NH_3 (Ammonia)	1.9

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[16] *This is not intended to imply that there is general agreement amongst environmental management community that the WBSCD indicators are the most appropriate or useful environmental indicators to apply.*

CO_2 equivalents are a measure used to compare the emissions from various greenhouse gases based on their global warming potential (GWP) relative to CO_2. GWPs compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. GWP thus provides a common unit to describe the environmental impact of the emissions from the motor industry in terms of their contribution to global warming. Box 6.2 describes how GWP is used to calculate global warming impacts.

Similarly, SO_2 equivalents are a measure used to compare the emissions of various gases based on their acidification potential (AP) relative to SO_2. AP compares the ability of each gas to cause acidification effects in the environment (e.g. acid rain) relative to another gas. AP thus provides a common unit to describe the environmental impact of the emissions from the motor industry in terms of their contribution to global acidification. Box 6.3 describes how AP is used to calculate acidification impacts.

6.2 Summary

In 2000, a total of 122.21 Mt of emissions to air were produced by the motor industry for the indicator emissions examined, of which 119.69 Mt were from the use of road transport (NETCEN, 2003a)[17]. Table 6.4 provides a summary of masses air emissions calculated for different motor industry activities in 2000. The results are represented graphically in Figure 6.1. A breakdown of the masses of selected air emissions released by different motor industry activities is presented in Table 6.5.

Table 6.4 Summary of air emissions for the motor industry in 2000

UK motor industry: production	*UK motor industry: transport (use)*	*UK motor industry: total*	*Total emissions for the UK*
Air emissions (Mt)			
2.52	119.69	122.21	570.76
Air emissions expressed as a % of all motor industry emissions			
2.1%	97.9%	100%	–
Air emissions expressed as a % of total UK air emissions			
0.4%	21.0%	21.4%	100%

Source: NETCEN, 2003a; ONS, 2003a.

Box 6.2 Global warming potential

Global Warming Potentials (GWPs) describe the radiative forcing of 1 kg of gaseous emissions relative to that of 1 kg of carbon dioxide. In effect, this provides a measure of the amplification of the natural phenomenon of global warming by the increase in emissions of greenhouse gases from anthropological sources. In other words, it describes the contribution towards global warming from the system studied (in this case, the UK motor industry). The values are updated periodically by the Intergovernmental Panel on Climate Change (IPCC). Since the observed effect on global warming changes with time, GWPs are available to assess the potential effects of emissions for a 20, 100 and 500 year period. The table shows the GWPs for some of the emissions assessed in this mass balance study.

GWPs for selected greenhouse gases for 100 year time horizon (Houghton *et al.*, 1996)

Greenhouse gas	*GWP*
Carbon dioxide (CO_2)	1
Methane (CH_4)*	21
Nitrous oxide (N_2O)	310
HFC-23	11,700
HFC-32	2,800
HFC-125	1,300
HFC-134a	3,800
HFC-143a	140
HFC-152a	2,900
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
SF_6	23,900

It should also be noted that although it appears from this table that CO_2 has the least effect on global warming, it is in fact the most significant greenhouse gas and has a great deal of influence on the observed global warming effect. This is because it is a much more abundant gas in the atmosphere than the others in the list. For example, the UK as a whole emitted about 571 Mt of gases to air in 2000, of which more than 559 Mt were CO_2.

Source: Houghton et al., 1996.

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[17] *These figures change to 134.82 Mt and 113.23 Mt respectively when ONS Environmental Accounts are used as an alternative data source (ONS, 2003). The NETCEN data was preferred, since it provides a breakdown of the types of emissions generated by the motor industry. However, the totals calculated using the NETCEN method are less than those quoted by ONS and underestimate emissions by 2.98% and 3.05% respectively. Sources for data presented included: ONS, 2003; NETCEN, 2003; e-Digest of Environmental Statistics (ONS/DEFRA, 2003).*

Box 6.3 Acidification potentials (AP)

Acidification impacts are caused by the release of hydrogen ions (H+). This is a natural process which is amplified by pollutants from human activities. Acidifying pollutants have a wide range of effects on the environment, including damage to soil, water, ecosystems and the built environment. The potential to form hydrogen ions should be assessed (following the work of Heijungs *et al.*, 1992), and the following factors have been used in the assessment:

- One mole of SO_2 forms two moles of H+.
- One mole of NO_x forms one mole of H+.
- One mole of NO_3^- forms one mole of H+.
- One mole of NH_3 forms one mole of H+.
- One mole of HCl forms one mole of H+.

The acidification potential of a substance *i* is defined as the potential number of H+ ions produced per kg of substance *i* relative to SO_2.

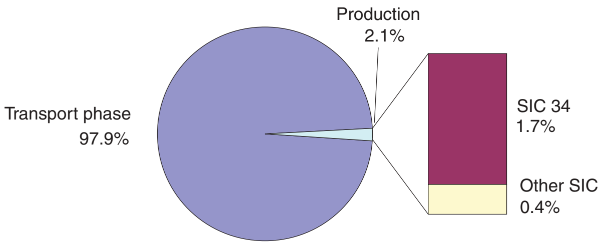
However, this approach considers the maximum possible acidification potential of a substance, whereas the actual impacts will be governed by a number of local environmental characteristics, not least the capacity of the environment to buffer such acidic inputs. The actual acidification caused by NO_x and NH_3 can vary widely according to the environment in which they are released. If anions are present in abundance, they will act as a buffer against the acidification effects of these emissions. They may also be removed by biomass.

A number of different ways of dealing with this uncertainty have been put forward, but there is no agreement as yet on a best practice means of assessment. However, in dealing with impact assessment at the national level, it is prudent to use the maximum possible acidification potential, since policies are not usually site specific and this represents a precautionary approach.

Factors used to calculate acidification potentials (APs) of common air emissions

Emission to air	*AP*
Ammonia (NH_3)	1.88
Nitrogen oxides (NO_x as NO_2)	0.7
Sulphur oxides (SO_x as SO_2)	1
Hydrogen chloride (HCl)	0.88
Hydrogen fluoride (HF)	1.6

Source: Heijungs et al., 1992.



Source: NETCEN, 2003a; ONS 2003a.7

Figure 6.1 Air emissions for motor industry activities expressed as a percentage of the total emissions for the UK motor industry in 2000

Table 6.5 Breakdown of emissions to air from the UK motor industry in 2000 (tonnes)

Emission to air	*Vehicle manufacture (SIC 34)*	*Tier 1 supplier (all other relevant SIC codes, including SIC 35.4)*	*Total production*	*Transport*	*Total emissions for the UK*
Carbon dioxide, CO_2	2,020,000	448,236	2,468,236	115,692,243	559,392,000
Methane, CH_4	150	30	179	15,560	2,322,900
Nitrogen dioxide, NOx	87	16	104	628,540	1,742,000
Sulphur dioxide, SO_2	1,675	955	2,630	5,890	1,188,000
Ammonia, NH_3	12	9	21	12,170	318,960
Nitrous oxides, N_2O	6,272	1,287	7,560	12,730	144,000
Particulate matter, PM_{10}	468	283	751	26,480	171,950
Carbon monoxide, CO	13,990	2,766	16,756	2,880,430	4,031,000
Volatile organic compounds, VOC	18,340	2,457	20,797	408,060	1,419,000
Benzene, C_6H_6	49	9	58	7,630	17,020
1-3 Butadiene, C_4H_6	22	3	25	4,550	5,880
Lead, Pb	0.40	0.38	0.78	326	496
Cadmium, Cd	0.01	0.02	0.02	0.31	6
Mercury, Hg	0.01	0.04	0.06	n/a	9
Arsenic, As	0.24	0.07	0.31	n/a	35
Chromium, Cr	0.09	0.08	0.17	0.31	63
Copper, Cu	0.12	0.05	0.17	0.51	46
Nickel, Ni	0.48	0.40	0.88	1.11	115
Selenium, Se	0.07	0.07	0.15	0.31	50
Zinc, Zn	1.02	0.29	1.31	0.67	337
Hydro-fluorocarbon, HFCs	0.22	0.44	0.66	n/a	1,811.80
Perfluorocarbons, PFCs	n/a	0.01*	0.01*	n/a	91.43
Sulphur hexafluoride, SF6	n/a	12.50*	12.50*	n/a	0.01
Total			2,517,134	119,694,612	570,755,770

** Data available only for some industries.*
Sources: ONS, 2003a; NETCEN, 2003a; ONS/DEFRA, 2003.

This represents 21% of the emissions from the UK as a whole. This is an important finding and suggests that reducing emissions from road transport is a priority, in order for the environmental impacts of the sector to be reduced significantly. Road transport emissions to air are of great concern for the Government which, in its recent Energy White Paper (DTI, 2003*)*, acknowledge that transport (including aviation) contributes about a quarter of the total UK carbon emissions.

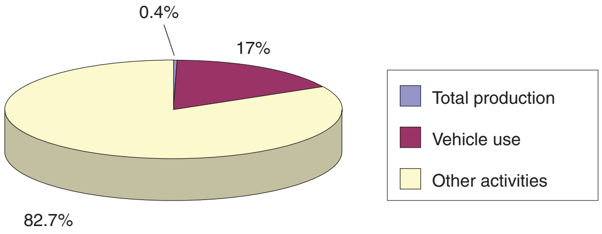
To describe the effects of the emissions in terms of acidification and global warming, the greenhouse gases and acid gases released by the motor industry have been described by their AP and GWP respectively in Table 6.6. In order to compare the effects caused by the motor industry with those experienced as a result of all UK emissions of these gases, the percentage contribution of the motor industry is illustrated in Figure 6.2 and Figure 6.3. The data illustrate that:

Table 6.6 Indicators used to assess some global environmental impacts (global warming, acidification) of the UK motor industry emissions in 2000

Indicator	*Vehicle manufacture (SIC 34)*	*Tier 1 supplier (all other SIC codes, including SIC 35.4)*	*Total production*	*Vehicle use*	*Total emissions for the UK*
Global warming potential (tonnes of CO_2 equivalent)	2,051,542	531,090	2,582,632	119,965,303	707,400,000
Percentage of total UK emissions	_	_	0.4%	17%	100%
Acidification potential (tonnes of SO_2 equivalent)	6,060	1,868	7,928	466,074	3,530,000
Percentage of total UK emissions	_	_	0.2%	13%	100%

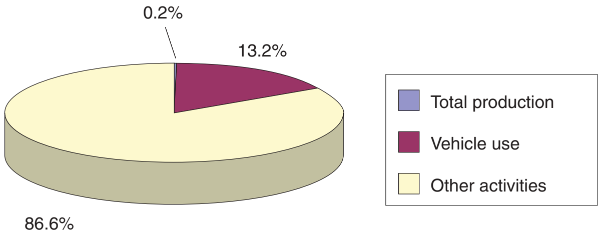
- Vehicle use (transport) is the part of the motor industry responsible for most of the potential environmental impacts associated with global warming and acidification.

- Vehicle use is responsible for 16.9% of the potential global warming and 13.2% of the potential acidification impacts associated with emissions for the whole of the UK. This is highly significant.



Source: ONS, 2003a; NETCEN, 2003a; ONS/DEFRA, 2003; Houghton et al., 1996

Figure 6.2 Global warming potential of motor industry production and vehicle use expressed as percentage of total UK production in 2000



Source: ONS, 2003a; NETCEN, 2003a; ONS/DEFRA, 2003; Heijungs et al., 1996

Figure 6.3 Acid rain precursors from motor industry production and vehicle use expressed as percentage of total UK production in 2000

6.3 Air emissions from production

Table 6.7 shows a selection of motor industry emissions by activity. It can be seen that the most significant emissions are greenhouse gases, particularly CO_2. Table 6.8 shows the breakdown of total emissions by activity type expressed in terms of GWP. As expected, the major contribution to the total air emissions come from the use phase of the motor industry, while by comparison, the production phase is fairly insignificant. This is confirmed by a recent life cycle assessment study, where vehicle use was responsible for 86% of CO_2 emissions during the life cycle of a car (see Box 6.4).

6.4 Air emissions from vehicle use

Table 6.9 presents the total emissions from transport, compared to the emissions from the whole of the UK. The most significant emissions are discussed in detail in this section.

Road transport produces 44.8% of the total UK benzene emissions and 77.4% of the total 1-3 butadiene produced in the UK in 2000. The main concern with these emissions is that they are both known to be potent human carcinogens.

Production of NO_x from vehicle use accounts for 36.1% of the total UK emissions in 2000, while the CO produced amounts to 71.5% of total emissions. NO_x are acid gases and ozone precursors mainly originating from combustion of motor spirit, diesel and coal. They can also adversely affect human health and vegetation. CO is highly poisonous, having adverse effects on all life, while it is also involved in low level ozone formation.

This illustrates that there is great value in examining air emissions in detail and establishing their contribution towards specified environmental problems. This allows the identification and prioritisation of the most serious environmental problems facing the industry as a result of vehicle use, rather than attempting to reduce all emissions simultaneously. In this sense, it is a pragmatic approach to allocating limited budgets to environmental protection and is of great use in environmental policy formulation. This type of approach is demonstrated most clearly in life cycle assessment methodology, where impact assessment is an integral part of the analysis.

The data presented in Table 6.10 and Table 6.11 take selected emissions from Table 6.9 to give a breakdown of the emissions associated with each vehicle type[18] (ONS/DfT, 2002). The data clearly demonstrate that for many of the emissions, car use was responsible for the largest proportion (60-91%) of the total emissions from road transport.

The exception to this is for PM_{10}, where LGVs, cars and HGVs are responsible for approximately 90% of the emissions, with each vehicle class responsible for about a third of the emissions each. However, given that there are many more cars on the road than either of the other two classes (cars are roughly an order of magnitude more numerous), each LGV or HGV on the road emits approximately ten times more PM_{10} than each car (see Chapter 4 for the actual vehicle numbers). Buses have been criticised for particulate and black smoke emissions in the past, and recent advances in technology have provided a means of minimising them (see Box 6.5). However, another considerable source of particulate matter is tyre and brake pad wear (see Box 6.6). This can be influenced by driver behaviour, since the speed at which vehicles are travelling can influence the particulate emissions considerably.

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[18] *The emissions were allocated to vehicle types where the data were available to do so. This was not the case for all of the emissions included in the mass balance.*

Table 6.7 Selected air emissions from the motor industry by activity and type in 2000 (t)

		Carbon dioxide	*Methane*	*Nitrous oxide*	*Other greenhouse gases (excluding CO_2, CH_4, N_2O)*	*Sub-total*	*Particulate matter*
Ref	*Activity**	CO_2	CH_4	N_2O	*HFC, PFC,* SF_6		PM_{10}
1	Use phase: road transport	115,692,243	15,560	12,730	0	*115,720,533*	26,480
2	Production phase: SIC code 34 (Motor industry: production of vehicles and parts)	2,020,000	150	87	0.2	*2,020,237*	468
3	Production phase: SIC code 35.4 (Motorcycles)	3,046	0.2	0.1	<0.1	*3,046*	0.5
4	Production phase: SIC code 17.5 (Textiles)	148,667	7.6	2.9	<0.1	*148,678*	29.9
5	Production phase: SIC code 25.1 (Rubber and rubber products)	82,240	3.9	2.9	<0.1	*82,247*	29.5
6	Production phase: SIC code 25.2 (Plastic and plastic products)	27,200	2.1	1.4	0.4	*27,204*	8.2
7	Production phase: SIC code 26.1 (Glass)	14,190	0.8	0.1	<0.1	*14,191*	7.9
8	Production phase: SIC code 27.5 (Casting of metals)	46,355	3.4	2.8	2.3	*46,363*	173.1
9	Production phase: SIC code 28.4 (Fabricated metal products)	66,223	5.6	3.6	<0.1	*66,232*	17.8
10	Production phase: SIC code 31.6 (Electrical equipment)	60,284	6.2	2.6	10.2	*60,303*	16.3
11	Production phase: SIC code 32.3 (Radio)	31	0	0	<0.1	*31*	0
Total		118,160,479	15,740	12,833	13.1	*118,189,066*	27,231

** For all activities, only data related to SIC codes with relevance to the motor industry are included. See Appendix 3 for further details.*
Sources: ONS, 2003a; NETCEN, 2003a; ONS/DEFRA, 2003.

Table 6.8 Breakdown of selected air emissions from the motor industry expressed in terms of GWP by activity and type in 2000 (t of CO_2 equivalents)

		Carbon dioxide	*Methane*	*Nitrous oxide*	*Other greenhouse gases (excluding CO_2, CH_4, N_2O)*	*Sub-total*
Ref	*Activity**	*CO_2*	*CH_4*	*N_2O*	*HFC, PFC, SF_6*	
1	Use phase: road transport	115,692,243	326,760	3,946,300	N/A	*119,965,303*
2	Production phase: SIC code 34 (Motor industry: production of vehicles and parts)	2,020,000	3,142	27,066	1,334	*2,051,542*
3	Production phase: SIC code 35.4 (Motorcycles)	3,046	4	19	2	*3,071*
4	Production phase: SIC code 17.5 (Textiles)	148,667	160	914	73	*149,813*
5	Production phase: SIC code 25.1 (Rubber and rubber products)	82,240	81	894	22	*83,237*
6	Production phase: SIC code 25.2 (Plastic and plastic products)	27,200	43	449	2,144	*29,836*
7	Production phase: SIC code 26.1 (Glass)	14,190	17	38	3	*14,248*
8	Production phase: SIC code 27.5 (Casting of metals)	46,355	71	857	13,758	*61,042*
9	Production phase: SIC code 28.4 (Fabricated metal products)	66,223	117	1,131	169	*67,640*
10	Production phase: SIC code 31.6 (Electrical equipment)	60,284	129	805	60,907	*122,125*
11	Production phase: SIC code 32.3 (Radio)	31	0	0	47	*79*
Total		118,160,479	330,526	3,978,472	78,458	*122,547,935*

** For all activities, only data related to SIC codes with relevance to the motor industry are included. See Appendix 3 for further details*

Box 6.4 Carbon dioxide emissions through the life cycle of a car

A study from a manufacturer showing the split in CO_2 emissions produced by a Japanese car in its life (2000 cc, assumed to travel 94,000 km over the vehicle life) was as follows (Suzuki, 2003):

- Materials production (7%).
- Vehicle assembly (4%).
- Transporting the vehicle (2%).
- Scrapping the car and recycling it (0.04%).
- Using the car (86%).

Thus, action to reduce CO_2 emissions over the whole car life cycle would be best focussed on reducing emissions in use rather than any other activity. In vehicle engineering terms, some solutions would be to make the vehicle lighter or to change to a different fuel source. However, this conclusion takes no account of the availability of alternative transport technologies available to travel the distances quoted. At a policy level, it may be that a more expedient means of reducing the emissions in an organisation or country would be to encourage a shift towards using less polluting alternatives to the car, where multiple transport modes are available.

Source: Suzuki (2003).

Table 6.9 Air emissions from UK transport use in 2000 (from Table 6.5)

Emissions to air, tonnes:	*Transport*	*Total UK*	*Contribution from transport in %*
Carbon dioxide, CO_2	115,692,243	559,392,000	20.7%
Methane, CH_4	15,560	2,322,900	0.7%
Nitrogen oxides, NO_x	628,540	1,742,000	36.1%
Sulphur dioxide, SO_2	5,890	1,188,000	0.5%
Ammonia, NH_3	12,170	318,960	3.8%
Nitrous oxides, N_20	12,730	144,000	8.8%
Particulate matter, PM_{10}	26,480	171,950	15.4%
Carbon monoxide, CO	2,880,430	4,031,000	71.5%
Volatile organic compounds, VOC	408,060	1,419,000	28.8%
Benzene, C_6H_6	7,630	17,020	44.8%
1-3 Butadiene, C_4H_6	4,550	5,880	77.4%
Lead, Pb	326	496	65.6%
Cadmium, Cd	0.31	6	5.3%
Mercury, Hg	n/a	9	n/a
Arsenic, As	n/a	35	n/a
Chromium, Cr	0.31	63	0.5%
Copper, Cu	0.51	46	1.1%
Nickel, Ni	1.11	115	1.0%
Selenium, Se	0.31	50	0.6%

Source: ONS Environmental Accounts (ONS, 2003), National Inventory (NETCEN, 2003a), e-Digest of Environmental Statistics (ONS/DEFRA, 2003).

Table 6.10 The contribution by mass of different vehicle classes to total emissions from road transport (kt)

Emissions, kt	*Cars*	*LGVs*	*HGVs*	*Buses*	*Motorcycles*	*Totals*
Benzene	6.96	0.41	0.00	0.00	0.26	7.63
CO	2,489.23	235.55	43.26	20.29	92.10	2,880.43
CO_2	69,522.60	15,901.20	24,193.47	5,464.07	610.90	115,692.24
NO_X	371.90	43.68	162.74	49.36	0.86	628.54
PM_{10}	7.90	8.94	7.36	1.82	0.46	26.48
VOC	333.55	24.72	28.78	6.56	14.45	408.06
CH_4	11.39	0.82	1.67	0.91	0.77	15.56

Table 6.11 Contribution in percentages by mass of different vehicle classes to total emissions from road transport

Emissions, % by weight	*Cars*	*LGVs*	*HGVs*	*Buses*	*Motor -cycles*	*Totals*
Benzene	91.2	5.4	0.0	0.0	3.4	100.0
CO	86.4	8.2	1.5	0.7	3.2	100.0
CO_2	60.1	13.7	20.9	4.7	0.5	100.0
NO_X	59.2	6.9	25.9	7.9	0.1	100.0
PM_{10}	29.8	33.8	27.8	6.9	1.7	100.0
VOC	81.7	6.1	7.1	1.6	3.5	100.0
CH_4	73.2	5.3	10.7	5.8	4.9	100.0

Box 6.5 Reducing emissions from London buses

In the early 1990s buses in London were severely criticised for being ‘dirty’. It was difficult to defend the service against this argument, as:

- 2,000 of the buses in operation were over 15 years old; and
- 500 were over 30 years old.

Since 1990, some impressive improvements been made to the fleet of buses used by London Buses Limited. This includes reducing ‘black smoke’ and other harmful pollutants from their vehicles. An on-going programme will see the whole fleet fitted with Euro II engines or better and diesel particulate filters by 2005. The improvements made include:

- Introduction of diesel particulate filters.
- Re-engineering of Routemasters.
- Exhaust Gas Recirculation is also being trialled with 10 vehicles.
- Fuel cell buses will be demonstrated from late 2003 on a London bus route.
- The development of a London bus test cycle.
- 100% use of Ultra Low Sulphur Diesel with current research looking into water-diesel emulsion (PuriNOX™).

TransportEnergy Clean Up has supplied grant assistance for the first three of the projects listed.

Source: TransportEnergy Powershift, 2003.

6.5 Discussion

The UK as a whole produced approximately 571 Mt of gaseous emissions in 2000, of which more than 559 Mt were comprised of CO_2. Converting the relevant gases to tonnes of CO_2 and SO_2 equivalents, this equates to over 707 Mt of greenhouse gases and 3.5 Mt of acid rain precursors. (NETCEN, 2003a; ONS/DEFRA, 2003). As outlined by the recent Government Energy White Paper (DTI, 2003a), the transport sector produces about a fifth of the total UK carbon emissions. Road transport is responsible for 85% of carbon emissions from the transport sector (i.e. of this fifth), with passenger cars accounting for about half of the carbon emissions for the entire transport sector.

Box 6.6 The effect of speed on particulate emissions from exhausts and vehicle tyre wear

Current vehicle type approval legislation requires the measurement of exhaust emissions of HC, CO, and NO_x for both diesel-engined and petrol-engined vehicles, though the mass-based measurement of total exhaust particulate is only defined in regulation for the former. Future legislation may require the regulation of particle emissions from petrol vehicles as well as diesel vehicles, but there are a number of reasons why alternatives to a solely mass-based standard are desired, and why the emphasis may change from particle mass to particle size and number. For example, the mass concentration of particles in the exhaust of diesel engines has reduced steadily over the last 20 years following the development and application of new technologies. Current and future legislation is reducing diesel and petrol particulate mass emissions, and diesel targets, towards the threshold of reliable measurement. In addition, mass-based standards alone are not ideal in terms of minimising the risks to health; it is the size of particles that determines how deep they penetrate into the human respiratory system and where they are deposited.

A new passenger car tyre weighs around 8kg, and loses roughly 1-1.5kg in weight during its service lifetime, which is typically around 3 years or 50-60,000km. Thus, between around 10% and 20% of the rubber which goes into a tyre will disappear before the tyre is ready to scrap (Environment Agency, 1998). Similarly, Ahlbom and Duus (1994) arrived at an average rubber loss figure for Swedish roads of 17%. Based on the upper estimate for rubber loss of 20%, a simple calculation reveals that around 90,000 tonnes of tyre material was lost to the UK environment during 1999, mainly as a result of in-service wear.

Source: Ahlbom and Duus, 1994; Environment Agency, 1998.

Some other pollutants, even though released in small amounts, have a disproportionately large effect on global warming potential. For example, N_2O releases from catalytic converters total 0.01 % of the total mass of air emissions from the use of vehicles. However, this equates to 3.3% of total global warming potential calculated for the use phase. However, because CO_2 is a much more abundant gas in emissions, it still largely determines GWP for the UK (see Box 6.2). The production phase of the UK Motor Industry accounts for only 0.37% of the total UK greenhouse gases emissions, while the use phase is estimated to contribute 16.96% (119.97 Mt of CO_2 equivalents).

Concerns must also be raised regarding the potential to form smog and the inherent toxicity of a number of emissions highlighted in this study. In the case of CO, C_4H_6 and C_6H_6, use of passenger cars is the single main source of these emissions.

Congestion is targeted in the 2000 'Transport 2010 – the Ten Year Plan' (DfT, 2000b), which aims to promote increased use of public transport and shift of goods traffic from road to rail through a programme of investments and innovation. Even if we assume that *all* LGV and HGV emissions can be avoided by a shift from road to rail, this only represents a reduction of 5 – 33 % on the current emissions, depending on the type of emission as listed in Table 6.11 (and 62% on particulates measured as PM_{10}). Although this is a worthwhile reduction in itself, this may not be sufficient to continually reduce air emissions in the longer term. As discussed in Section 6.4, passenger car use is responsible for the largest proportion of the emissions from vehicle use and this is likely to continue to rise, given that car ownership and miles travelled by passenger car are continuing to increase. The results suggest that greater emissions reductions may be achieved by encouraging a higher level of public transport use as an alternative to passenger car journeys.

The obvious conclusion from the analysis of the data on air emissions is that the UK motor industry can reduce the associated environmental impacts by reducing the emissions in the vehicle use phase. In terms of a policy approach to achieve this, there are a number of possibilities to explore:

- Producing vehicles with much lower exhaust emissions.

- Reducing the need for road transport.

- Using alternative cleaner fuels as an energy source.

Thus, UK policy options to reduce emissions must also take into account the question of energy supply issues for vehicle use because the two issues are always linked. Energy supply issues relevant to determining the level of emissions include:

- Energy efficiency of vehicles.

- Choice of fuels used to power vehicles.

The strategy underpinning the development of cleaner vehicles is described in the document 'Powering Future Vehicles' (DfT, 2002b), which aims to promote the development, introduction and take up of low carbon vehicles and fuels, whilst ensuring the full involvement of the UK automotive industry. The strategy sets targets such as sales of at least one in ten new cars with emissions of 100 g/km in the next decade and introduction of 20% of new buses with low-carbon fuels. Further discussion of cleaner fuels is provided in Chapter 8.

The environmental consequences of pursuing this strategy have also been evaluated and are discussed further in Chapter 8, along with policy options available for influencing energy supply and reducing emissions.

7 Wastes

7.1 Introduction

This chapter quantifies wastes arising from the:

- Production of vehicles and components.
- Use of vehicles (maintenance).
- Management of ELVs.

Commentary is limited to discussing wastes produced by the industry which are available for different waste management processes. The intention is to assess the environmental performance of arrangements to manage wastes arising from motor industry activities in 2000. This includes estimating the proportions of materials recovered by recycling and reuse in the industry. For this reason, the losses of fluids and tyre rubber during vehicle use are not discussed in this chapter.

For balancing the flow of material and resources into and out of the motor industry, figures related to the *arisings* of waste rather than *disposal* have been reported, because for the former the information available could be more exactly related to the SIC coding structure adopted elsewhere in the mass balance study. Some more detailed information about the waste management options adopted by the core activities of the motor industry as defined by SIC (34.1 to 34.3) is also given. This allows a better assessment of the potential environmental impact of the industry.

Wastes arise in four forms - solid, sludge, liquid and aqueous[19]. Solid, sludge and liquid wastes are primarily regulated and monitored by the Environment Agency[20]. It has been possible to identify solid wastes for all the mass balance stages identified. In addition, it has been possible to identify liquid and sludge wastes arising from production activities, as well as fluids arising from vehicle maintenance and from management of ELVs.

Aqueous wastes are water-based wastes and can be discharged under one of two regulatory regimes:

- To sewer under a private agreement between a discharger and a sewerage undertaker.
- To ground or surface water under the terms of a 'consent to discharge' authorised by the Environment Agency[20].

Aqueous wastes are generally discharged to the public sewer system under the terms of a 'trade consent'. These consents are issued by the individual sewerage undertakers. Although the nature and quantities of these wastes has to be declared by those discharging the wastes to the undertaker, very few of these undertakers record the nature of the industry making the discharge. Accordingly it has not been possible to identify such discharges made by the motor industry within the resources available to thizs study.

Further details of the methodology used to determine the arisings of wastes presented in this chapter are given in Box 7.1.

Data on those waste arisings falling within the remit of the Environment Agency are given in the recently published Strategic Waste Management Assessments (Environment Agency, 2000b). They are based on 1998 data and on national surveys of waste arisings (see Appendix 4). Whereas double counting has been avoided in quantifying material resource use (see Section 4), a different approach was required in respect of waste generation. In quantifying waste generation, wastes generated at all stages of the production, use and disposal of vehicles have been included. Therefore, the calculation *includes* waste production at those stages that were removed from resource consumption calculations to avoid double counting.

Only a relatively small but significant percentage of wastes arising from vehicle maintenance and ELVs[21] are sent for final disposal. The figures presented include materials available for reuse and reprocessing activities. Examples of such materials are metals from shredded vehicles sent for reprocessing at smelters.

7.2 Summary

This study has found that the total mass of waste arising from the motor industry in 2000 was 7.21 Mt, with 50% originating in production of vehicles and parts, 19% arising during vehicle use and maintenance (as used components and fluids) and 31% from end of life vehicles (ELVs).

The total waste arising from the production stage was estimated to be 3.58 Mt. 88% of the waste arising from

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[19] *Solid, sludge and liquid wastes are primarily regulated and monitored by the Environment Agency, under the provisions of waste management legislation. Aqueous wastes are defined as those discharged to sewer by private agreement with a sewerage undertaker, or discharged to ground or surface water under authorisation from the Environment Agency. Therefore in this report, although liquid wastes include some water-based wastes, the description only includes those which cannot be discharged to sewer, ground or surface waters and are sent to waste management facilities for storage and/ or treatment instead.*

[20] *Or equivalent agency in the rest of the UK.*

[21] *That is, both statutory and non-statutory.*

Box 7.1 Methodology

Waste from production

Data on solid, sludge and liquid waste arisings associated with motor industry parts and vehicle manufacture were sought from the Environment Agency on the basis of the definition of the motor industry presented in Chapter 1 and Appendix 1.

The Environment Agency has published on its website a Waste Benchmarking Tool which allows businesses to compare their waste production with the national average. For every SIC code (down to three digits), the tool gives a detailed description (quantities and quality) of the average waste material produced per company or per employee, after subdividing businesses in 4 employees size bands.

Using the available statistics on active businesses, published in the ONS PA1003 (ONS, 2001b), it is possible to estimate the waste arising down to SIC classification level required in this study. Further details of the method are given in Appendix 4.

Combining the tool with the statistics on businesses number for the whole of the UK gives a good estimate of the waste generated by the production phase of the motor industry.

It must be noted that the Waste Benchmarking Tool derives its data from the 2000 SWMA for England and Wales, which reports data for the year 1998. Two major assumptions have therefore been made when calculating the arising in the whole of the UK for the year 2000:

1 Levels of waste arising in 2000 were similar to 1998.

2 Businesses active in NI and Scotland produce the same amount of waste as their English and Welsh counterparts.

Waste arising as replacement parts

For every replacement component sold, it has been assumed that a used component must be removed, and then is managed by any one of a number of waste management processes. By identifying the numbers of components of each type that were sold in 2000, along with their average weights, the size of the waste stream can be estimated. However, there were no figures available to describe the mass of components used in maintenance activities available from any source. For this reason, a separate study was conducted to examine the types of components replaced over a yearly period for vehicle maintenance and the proportion of the total aftermarket production this accounted for. Further details are given in Appendix 4.

Waste arising as ELVs

A model has been devised to determine ELV arisings in 2000 for all vehicle classes and estimate the mass this equates to. Estimates have also been made to allocate the numbers of vehicles and masses geographically for Great Britain and Northern Ireland. The number of ELVs arising in 2000 can be calculated from the equation:

ELV Arisings in 2000 = (A + B) – (C + D)

Where: A = Vehicle stock at the end of 1999
B = New registrations in 2000
C = Vehicle stock at the end of 2000
D = Exports

To facilitate the calculations a number of assumptions have been made. These are set out in Appendix 3, with a full description of the methodology used to create the model.

Sources: Environment Agency, 2000b; ONS, 2001.

the production phase arises from activities falling within the description of SIC 34 (3.14 Mt). Since these industrial activities make the largest contribution to the total mass arising from production, they have been examined in more detail to determine the potential to recycle materials. Metals and metallic scrap equipment constitutes the largest share of the waste arising from the SIC 34 activities included in this study. On this basis, it has been estimated that 1.38 Mt of waste arising from these activities would be capable of recycling, being comprised of metals, paper and card. The data were insufficient on other waste streams to determine the potential for recycling. For these reasons, the mass quoted is likely to be an underestimate.

For the use phase, a survey was conducted to determine the components and fluids arising for all vehicle types during an average year due to maintenance. This amounted to approximately 1.03 Mt of components[22] and 0.15 Mt of fluids[23], of which it is estimated that 0.62 Mt and 0.13 Mt are currently recycled respectively, given constraints imposed by lack of recycling infrastructure and markets for recyclate. The replacement parts and fluids used during 2000 are already included in the total production figures (see Chapter 4) and were not counted as additional mass there. However, they have been included as additional mass in the waste arisings, because they are not included within waste arising from production or ELV arisings. Thus though they are presented in Chapter 4 and presented here again for completeness, they have not been counted twice in the mass balance calculation.

2.25 Mt of waste arose from all ELVs in 2000. Of this figure, it is estimated that 1.73 Mt is currently recycled, given the current recovery infrastructure within the UK. This figure is expected to rise significantly in future, in line with the recycling and recovery targets imposed by the ELV Directive.

Tables 7.1 and 7.2 summarises the waste production by the motor industry and its management.

Of the waste arising from production, 21% is classified as Special Waste, and is closely regulated due to its hazardous nature. There was a lack of detailed data on ELV arisings which meant that a similar comparison of special waste arisings was not possible. It was not possible to determine the special waste arising from the other stages in the mass balance, as this would have required detailed information on the composition of waste streams, which was not available.

To put the impact of the production of vehicles and components into perspective, it must be noted that the industrial sectors in the UK produced 428.6 Mt of waste in 1998, of which 11% arose from the manufacturing sectors (ONS, 2003a). However, this is the part of the motor industry giving rise to the largest proportion of waste arisings, of which approximately one fifth are comprised of special waste.

It would seem that the product design stage should perhaps be subject to further policy and legislative activities in the future. The objective would be to ensure that consideration is given to designing out waste production when products reach the end of their useful life. Measures should include incentives to design out potentially hazardous materials. Choosing materials carefully for designing new vehicles and components, would also be beneficial, in order to allow more recovery activities during maintenance and at the end of life. This would assist other actors in the industry dealing with replacement parts and ELVs to increase the level of material recovery in the sector, thus meeting the requirements of producer responsibility legislation in future.

Table 7.1 Summary of management of waste from the motor industry in 2000 (Mt)

	Waste produced	*Reuse*	*Recycling*	*Disposed*
Production	3.58	0	1.38	2.20
Vehicle maintenance	1.18	0	0.75	0.43
ELVs	2.25	0.15	1.73	0.37
Total*	7.01	0.15	3.86	3.00

** Excludes tyre rubber and fluids lost during vehicle use.*

Table 7.2 Total waste production by the motor industry in 2000

	Mass (Mt)	*%*
Waste arising from production	3.58	50
Waste arising during maintenance as components and fluids	1.18	16
Waste arising as ELVs	2.25	31
Waste arising during use*	0.20	3
Total	7.21	100
Total available for processing#	7.01	97

** Fluids and tyre rubber lost during use.*

 # It is estimated that 4.01 Mt is available for recovery.

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[22] *This figure does not include 0.15 Mt of components originally sourced from ELVs. This mass has not been included here as the mass is already included in the mass of ELVs arising in this section.*

[23] *This does not include losses during use which have been reported in top level mass balance, shown diagrammatically in Chapter 2, Figure 2.1. Fluids lost during use are estimated at 0.12 Mt., while loss of tyre rubber accounts for 0.08 Mt. (Hird et al., 2002).*

7.3 Wastes arising from the production of parts and vehicles

The methodology used to calculate the waste arising from the production of parts and vehicles is presented in Box 7.1. Using this method, the production phase of the motor industry is estimated to produce around 3.58 Mt per annum of waste (including Special Waste). Table 7.3 illustrates the share of waste arisings allocated to each SIC code used for production activities in the motor industry.

A breakdown of the arisings in solid, liquid and sludge form is presented in Table 7.4. Solid waste represents the largest share of the arisings, at 77% of the total mass. Table 7.3 illustrates that the main source of all waste arisings is SIC code 34, which is dominated in terms of waste arising by the manufacturing of parts and accessories and motor vehicles. Box 7.2 discusses waste arising and efficiency in motor vehicle production.

Wastes from SIC 34 codes dominate the wastes generated by the manufacture of parts and vehicles accounting for 88% of the total. The material composition of the waste generated by the SIC 34 sector is outlined in Table 7.5 and illustrated in Figure 7.1.

Metals (ferrous and non-ferrous) constitute about 43% of all the waste generated by the SIC 34 activities, for a total of about 1.35 Mt of waste. These materials are likely to be recycled either straight back into the process or sold for

Box 7.2 Waste arising and efficiency in production

Anecdotal evidence suggest that in the past, materials cut off during production accounted for up to 40-60% equivalent of the body in white. New practices and different materials choice have now improved the situation: for example, casting is now preferred over other types of fabrication, and cut offs are recycled straight back into production for aluminium structures.

Different choice of structural materials, however, may have different impacts on the waste arisings and recycling performances (including recyclability of the vehicles itself): the move towards more efficient and therefore less polluting lighter vehicles implies more widespread use of plastics and composites. Moulding and lamination are likely to give a reduced amount of cut offs, which may however be difficult to recycle (thermosetting resins, carbon fibres). It is also likely that the recyclability of ELVs composed of materials such as carbon fibre composites is likely to be significantly reduced.

Source: Jaguar Cars Limited, 2003; Foresight Vehicle Programme, 2003.

Table 7.3 Total waste arising from the production phase in 2000

	Waste tonnage (t)				
Material or activity	*England and Wales*	*Scotland*	*Northern Ireland*	*Total for UK production*	*% of UK production*
SIC code 34.1: Manufacture of motor vehicles	1,009,722	71,903	30,018	1,111,643	31.1
SIC code 34.2: Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	295,901	21,071	8,797	325,769	9.1
SIC code 34.3: Manufacture of parts and accessories for motor vehicles and their engines	1,544,401	109,978	45,914	1,700,293	47.5
SIC code 35.4 Motorcycles	915	65	27	1,008	<0.1
SIC code 17.5 Textiles	10,498	748	311	11,556	0.3
SIC code 25.1 Rubber and rubber products	27,507	1,959	817	30,283	0.8
SIC code 25.2 Plastic and plastic products	16,584	1,181	493	18,258	0.5
SIC code 26.1 Glass	4,050	288	122	4,460	0.1
SIC code 27.5 Casting of metals	324,012	23,073	9,758	356,843	10.0
SIC code 28.4 Fabricated metal products	10,958	780	324	12,063	0.3
SIC code 31.6 Electrical equipment	5,396	384	158	5,939	0.2
SIC code 32.3 Radio	27	2	1	30	<0.1
Total production	3,249,971	231,433	96,741	3,578,145	100.0

Table 7.4 Waste arising as solid, liquid and sludge from the manufacture of parts and vehicles in 2000

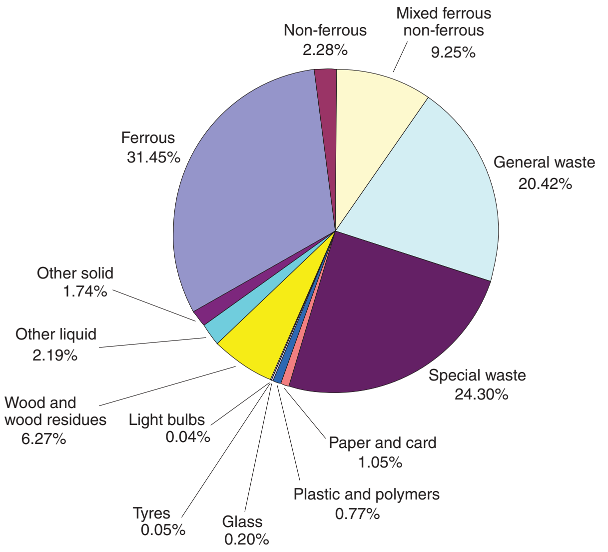
	Waste tonnage (t)			
Material or activity	*England and Wales*	*Scotland*	*Northern Ireland*	*Total UK*
Solid				
SIC code 34.1: Manufacture of motor vehicles	707,617	50,390	21,037	779,044
SIC code 34.2: Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	264,819	18,858	7,873	291,550
SIC code 34.3: Manufacture of parts and accessories for motor vehicles and their engines	1,126,017	80,185	33,476	1,239,678
SIC code 35.4 Motorcycles	914	65	27	1,006
SIC code 17.5 Textiles	10,443	744	309	11,495
SIC code 25.1 Rubber and rubber products	25,508	1,816	759	28,083
SIC code 25.2 Plastic and plastic products	15,083	1,074	449	16,606
SIC code 26.1 Glass	4,047	288	121	4,456
SIC code 27.5 Casting of metals	321,815	22,917	9,693	354,425
SIC code 28.4 Fabricated metal products	10,344	737	306	11,386
SIC code 31.6 Electrical equipment	5,178	369	152	5,699
SIC code 32.3 Radio	27	2	1	30
Total production	2,491,812	177,444	74,203	2,743,458
Liquid				
SIC code 34.1: Manufacture of motor vehicles	284,819	20,282	8,468	313,568
SIC code 34.2: Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	31,082	2,213	924	34,219
SIC code 34.3: Manufacture of parts and accessories for motor vehicles and their engines	276,141	19,664	8,210	304,015z
SIC code 35.4 Motorcycles	z1	0	0	2
SIC code 17.5 Textiles	55	4	2	61
SIC code 25.1 Rubber and rubber products	1,952	139	57	2,149
SIC code 25.2 Plastic and plastic products	1,478	105	44	1,627
SIC code 26.1 Glass	4	0	0	4
SIC code 27.5 Casting of metals	1,177	84	35	1,295
SIC code 28.4 Fabricated metal products	615	44	18	677
SIC code 31.6 Electrical equipment	218	15	6	240
SIC code 32.3 Radio	0	0	0	0
Total production	597,541	42,551	17,763	657,856
Sludge				
SIC code 34.1: Manufacture of motor vehicles	17,286	1,231	514	19,031
SIC code 34.2: Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	0	0	0	0
SIC code 34.3: Manufacture of parts and accessories for motor vehicles and their engines	142,243	10,129	4,229	156,601
SIC code 35.4 Motorcycles	0	0	0	0
SIC code 17.5 Textiles	0	0	0	0
SIC code 25.1 Rubber and rubber products	46	3	1	51
SIC code 25.2 Plastic and plastic products	23	2	1	26
SIC code 26.1 Glass	0	0	0	0
SIC code 27.5 Casting of metals	1,020	73	30	1,122
SIC code 28.4 Fabricated metal products	0	0	0	0
SIC code 31.6 Electrical equipment	0	0	0	0
SIC code 32.3 Radio	0	0	0	0
Total production	160,618	11,438	4,775	176,831

Sources: Environment Agency, 2000b; ONS, 2001. See Appendix 4 for further details.

Table 7.5 Material composition of waste generated by SIC code 34 in 2000

Waste material	*Including*	*Arisings per annum (t)*
Ferrous	Steel, mixed ferrous, iron	986,867
Non-ferrous	Including mixed, aluminium and copper	71,413
Mixed ferrous-non ferrous	Including also vehicle parts and sharps	290,082
General waste	General industrial or commercial	640,697
Special waste	See Section 7.6	762,442
Paper and card	–	33,014
Plastic and polymers	–	24,042
Glass	–	6,360
Light bulbs	–	1,239
Tyres	–	1,558
Wood and wood residues	Including coated timebr and sawdust, sahvings and wood pulp	196,685
Other liquid	Including aqueous paints and other non-special liquid waste	68,755
Other solid	Including containers and other solid non- special waste	54,551
Total		3,137,705

Sources: Environment Agency, 2000b; ONS, 2001b. See Appendix 4 for further details.



Source: Environment Agency, 2000b; ONS, 2001b. See Appendix 4 for further details

Figure 7.1 Wastes from the manufacture of parts and vehicles (SIC codes 34.1 to 34.3)

treatment and reuse in the motor industry or other manufacturing industries. It is not however possible to quote exact figures regarding the quantities of waste metals arising from the production of vehicles and parts recycled back in the sector itself. Box 7.3 illustrates the fate of metals arising from industries within SIC 34 in more detail, in terms of available waste management options.

7.4 Wastes arising from vehicle use and maintenance

Determining the size of the replacement parts and fluids waste stream

As presented in Chapter 4, it has been assumed for the purposes of the mass balance methodology, that:

- The number of new components consumed in maintenance is equal to the number of waste components arising. However, some components lose mass during use, and this should be accounted for in calculations.
- The ONS figures derived for components imported, produced and exported for aftermarket applications include all parts used for vehicle maintenance, although they are not stated explicitly as a separate category.

Thus for every replacement component sold, it is assumed that a used component must be removed, and then is managed by any one of a number of waste management processes. By identifying the numbers of components of each type that were sold in 2000, along with their average weights, the size of the waste stream can be estimated. However, there were no figures available to describe the mass of components used in maintenance activities available from any source. For this reason, a separate study was conducted to examine the types of components replaced over a yearly period for vehicle maintenance and the proportion of the total aftermarket production this accounted for.

The large number of retail channels through which replacement parts are distributed makes it difficult to collect accurate sales data. Additionally, retail chains, such as fast-fit centres and franchised dealerships were found to be reluctant to supply commercially sensitive data.

Information was gathered on parts that are likely to be replaced annually from discussions with garage owners, dismantlers, manufacturers and relevant Associations. The information was applied to all vehicles. Further details of the methodology are in Appendix 4.

Box 7.3 Waste management options adopted by industries within SIC code 34.1 to 34.3 in England and Wales

The information presented in this box originates from the Environment Agency Waste Exchange/Material Calculator, which collects information on some of the potentially recyclable waste streams originating in the various planning regions. This tool uses data about location and waste type to help companies make use of waste produced by others, and therefore presents data only on significant amounts of waste produced.

The most significant waste stream produced by SIC codes 34.1 to 34.3 is metallic waste. A query on the calculator web tool gives the results shown in the table (data in tonnes; for missing Regions there is no relevant information). This demonstrates clearly that the majority of metallic waste is sent for recycling operations at the moment.

Information on disposal of metallic waste for SIC codes 34 (tonnes)

SIC code	Region	Disposal	Land Re-used	Recycled	Thermal	Treated	Unrecorded	Total
34.3	North West	216	20	15395	0	0	0	15631
34.3	Yorkshire & Humber	217	0	20078	0	2	0	20297
34.3	West Midlands	439	0	58297	546	0	0	59283
34.1	West Midlands	488	72	33796	0	18	0	34375
34.3	Wales	503	0	22303	0	45226	0	68032
34.3	South West	34	0	14253	0	0	3	14290

Sources: Environment Agency, 2000b; ONS, 2001b.

For components estimates for the size of the waste stream were made based on average component life-time data. If the average life-time of a component group is known, estimates can be made for the number of components of each type removed per vehicle per year based on the number of vehicles in use and average vehicle mileage.

The resulting wastes generated by vehicle use and maintenance activity are estimated to be as set out in Table 7.6. Further details of the methodology are described in Appendix 4.

Not surprisingly, cars have the highest mass of components replaced per year, because they make up the largest proportion of vehicles in the parc in 2000 by numbers and by mass. The types of components replaced on all vehicles are presented in Figure 7.2.

Table 7.6 Expected total waste arising from vehicle maintenance and use in 2000

Vehicle	*Total components arising (t)*	*Total fluids arising (t)**
Car	507,028	128,929
HGV	317,266	77,986
LGV	134,399	42,658
Bus	62,734	16,180
Motorcycle	6,151	3,241
Total	1,027,582	268,995

Sources: See Appendix 4 for details of the survey methodology
** This includes fluids lost during vehicle use.*

The replacement of tyres accounts for the largest mass of waste arising from vehicle maintenance. This may include retreaded, second hand tyres and tyres purchased abroad. The Used Tyre Working Group has estimated that 61% of used tyres arising were sent for reuse, recycling or recovery operations in 2000 (UTWG, 2003). A recent report has estimated that the rate of recycling is 90% for batteries from motor vehicles (Kollamthodi, *et al.*, 2003a). Figures for the recovery rates of the other components were not available, so elsewhere in the study 50% has been used as an estimate of the proportion of the waste components sent for reuse, recycled or recovered. Using these assumptions, the total mass of materials available for reuse, recycling or recovery from the replacement parts waste stream is 616 kt.

Of the 269 kt total fluids replaced in 2000 121 kt will be lost during use leaving 148 kt (AEA, 1999). Assuming that 90% of the fluids will be able to be reused (refined, laundered or used as fuel, with the remaining 10% being contaminants which were not part of the fluids as sold), the fluids available for recycling are estimated at 133 kt.

In addition to replacement components, vehicle servicing and maintenance also involves draining and replacing fluids at regular intervals. Typical fluids that

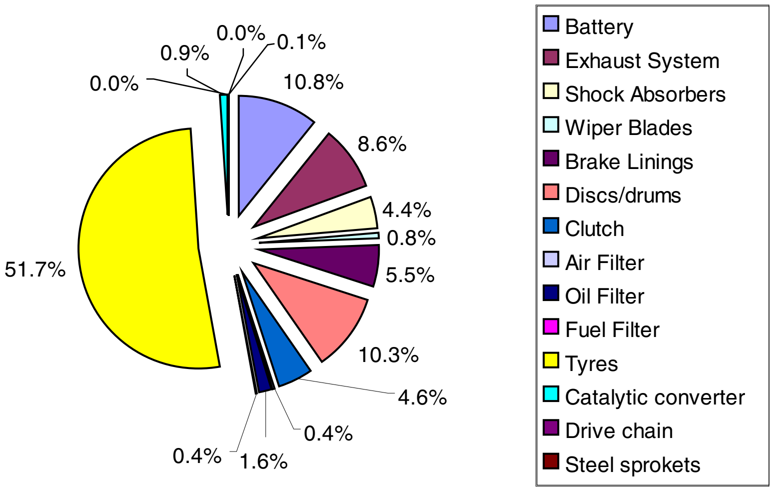


Figure 7.2 Parts replaced on all vehicles in 2000 (expressed as percentage by weight of all parts replaced)

are replaced include engine oil, coolant (antifreeze), and brake fluid. Estimates of the arisings of these waste fluids are provided in Table 7.6.

7.5 Management of vehicles at end of life

Arisings of statutory and non-statutory ELVs

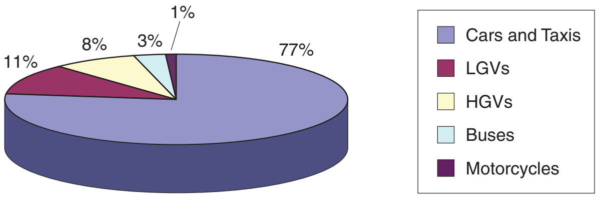
The model used to determine ELV arisings in 2000 is given in Box 7.1.

To facilitate the calculations a number of assumptions have been made. These are set out in Appendix 4, with a full description of the methodology used to create the model. Table 7.7 presents output from the model, which is the number and tonnage of arisings by vehicle type and geographical area in 2000. 2.25 Mt of ELVs were generated in the UK in 2000, with statutory ELVs (cars, taxis and LGVs) representing 89% of the total arisings by weight (see Figure 7.3). This indicates that most of the UK ELV arisings will be subject to the provisions of legislation to implement the ELV Directive when it is fully implemented in the UK, whose objective is to encourage more environmentally sound waste management practices in the motor industry.

Table 7.7 Estimated statutory and non-statutory ELV arisings

Vehicle type	*Total ELV arisings (Number of vehicles)*	*Total ELV arisings expressed as mass (tonnes)*
Cars and taxis	1,902,949	1,728,871
LGVs	207,020	254,470
HGVs	34,734	183,902
Buses	7,706	70,620
Motorcycles	118,339	16,955
All	2,270,749	2,254,817

Source: See Appendix 4 for details of data sources and calculation methods.



Source: See Appendix 4 for details of data sources and calculation methods

Figure 7.3 Mass of UK ELV arisings expressed by type, as a percentage by weight

The estimated 2.25 Mt of ELV arisings contains a variety of materials capable of being recovered. The materials available have been determined and the relative availability of routes for recovering or recycling the material has been summarised in Chapter 3. The infrastructure available for recycling and recovery operations largely determines the viability of separating and reusing materials, and this is discussed fully Chapter 8.

The resulting wastes generated by ELVs and available for processing and reprocessing activity are estimated to be as set out in Table 7.8 and illustrated in Figure 7.4. The figures have been calculated on the basis of average vehicle compositions presented in Table 4.3 (Chapter 4) and the numbers and masses of ELVs arising in each vehicle class.

Table 7.9 shows the results of a recent study conducted to determine the current level of reuse and recovery for a number of different materials arising from statutory ELVs. This gives an indication of the current infrastructure

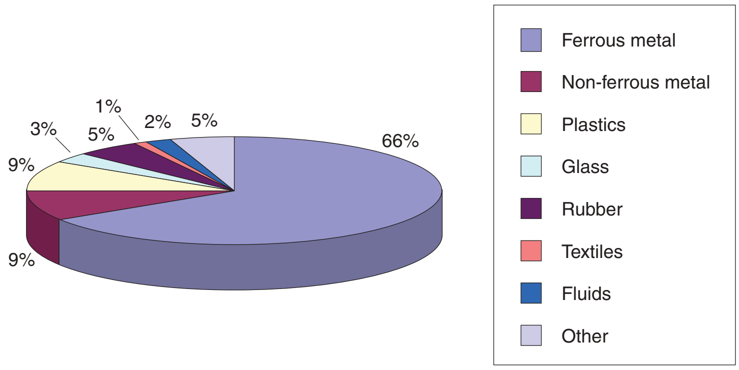
Table 7.8 Estimated mass of materials arising from ELVs

Materials (t)	*Cars and taxis*	*LGV**	*Bus*	*HGV*	*Motorcycle**	*Total available in UK*
Ferrous metal	1,175,632	162,606	102,617	56,425	8,138	1,505,419
Non-ferrous metal	138,310	29,518	43,033	3,460	5,087	219,408
Plastics	155,598	21,630	9,011	3,460	2,204	191,904
Glass	51,866	7,634	6,988	494	17	67,000
Rubber	86,444	12,723	8,276	3,955	1,356	112,754
Textiles	17,289	u/k	368	353	u/k	18,010
Fluids	34,577	u/k	1,839	918	u/k	37,334
Other	69,155	20,358	11,770	1,554	u/k	102,836
Total (t)	1,728,871	254,470	183,902	70,620	16,955	2,254,817

** Textiles, fluids and other materials account for 1% of the mass, but the proportions are unknown.*

u/k = Unknown.

Sources: See Table 4.4 and Appendix 4.



Source: See Table 4.4 and Appendix 4

Figure 7.4 Materials available from ELVs in 2000 (expressed as percentage by weight)

Table 7.9 Comparison of the material composition of a statutory ELV with the amount of statutory ELV material reused and recovered in 2000

Material/component stream	*Estimated percentage material composition of an ELV**	*Estimated current reuse and recovery as a percentage of the total tonnage of ELV arisings in 2000*	*Estimated current reuse and recovery as a percentage of estimated individual material arisings in 2000*
Components sold for reuse (including reuse of tyres)	n/a	6.69%	n/a
Ferrous metal	68%	63.73%	93.7%
Non-ferrous metal	8%	4.22%	52.7%
Plastics and process polymers	10%	0.10%	1.0%
Tyres (not including reuse)	3%	1.63%	54.3%
Glass	3%	0.10%[†]	Less than 3.3%[†]
Batteries	1%	n/a[#]	n/a[#]
Fluids	2%	0.40%	20.0%
Textiles	1%	~0%	~0%
Rubber	2%	~0%	~0%
Other	2%	u/k	u/k
Total	100%	76.87%	

** Source: ACORD, 2000.*

[†] *The percentage of glass reused or recovered has been assumed to be 0.1%.*

[#] *Battery reuse and recovery is included under component reuse, non-ferrous metal recycling and plastics recycling.*

u/k = Unknown.

Source: Kollamthodi et al., 2003b.

available for these materials. If it is assumed that the percentage by weight reused or recovered from statutory ELVs applies to all ELVs (76.87%), then 1.73 Mt of ELV arisings are currently recycled. It can be seen that infrastructure reusing and recovering metals and tyres is well established. It is also clear that the development of infrastructure to manage other material streams will require attention in future, if the resource productivity of the motor industry is to continue to increase. This will be necessary to meet the material recycling and recovery targets in the ELV Directive (Chapter 3). Further discussion of the implications of this requirement for integrated product policies is given in Chapter 8.

There is continuing innovation in vehicle manufacture and design, which may affect the materials entering the motor industry in future. This in turn will affect the materials arising as wastes for recovery in the future. Box 7.4 presents some of the issues raised by continuing innovation, while Chapter 8 considers how the development of integrated product policies can be expected to contribute to influencing material choices in future.

Box 7.4 New materials in vehicles

The switch towards more efficient vehicles is driving the research towards lighter body structures. This serves to counterbalance the trend for the weight of the vehicles to increase, due to the introduction of new electronic features and increasing vehicle sizes more generally. Some of the projects that are part of the Foresight Vehicles* programme, for example, are looking at developing new plastic based structures which would satisfy at the same time the requirements of lightness, crashworthiness, low environmental impact and affordability. Carbon fibres and other composites give the best performance in terms of structural properties, but may have low recyclability rates in comparison with single material structures. However, new highly recyclable composites are under development: they either contain as reinforcement natural fibres such as flax or fibrous version of the same polymer constituting the matrix.

A list of projects funded is available at www.foresightvehicle.org.uk.

* *Foresight Vehicles is the UK's national automotive R&D programme, which aims 'to promote technology and to stimulate suppliers to develop and demonstrate market driven enabling technologies for future motor vehicles (cars, taxis, HGVs, buses, light commercial vans, etc.) which must satisfy increasingly stringent environmental requirements as well as meeting expectations for safety, cost, performance and desirability' (Foresight Vehicle, 2003).*

Abandoned vehicles

Although abandoned vehicles are not evaluated as part of the mass balance, they have been quantified during the course of data collection in order to calculate statutory ELV arisings[24]. They have been presented in the report as there is currently a great deal of interest in the effect that falling steel prices have had on the arisings of these vehicles. Historical trends have suggested that numbers of vehicles abandoned have grown with the decrease in prices paid to the last owner. This situation has recently become even worse now that the last owner has to pay for the vehicle to be taken away (Kollamthodi *et al.*, 2003a).

Table 7.10 shows the total number of abandoned cars collected and disposed of in local authorities in 2000 (Kollamthodi *et al.*, 2003a). The cost of collecting an abandoned vehicle has been estimated at between £0-£150 (Kollamthodi *et al.*, 2003a). In reality very few contractors collect for free. However, £150 was only found to be charged by one contractor in the Highlands of Scotland due to the distances travelled. The average cost was around £30 per vehicle. All local authorities reported that the collection fee charged was increasing or about to increase, due to low scrap values. On top of collection costs, there is also the cost of disposal, storage and officer time. Local authorities that were able to provide this data reported total costs between £18 and £255. One local authority also expressed concern over the hidden costs as officers were spending an increasing amount of time dealing with abandoned vehicles at the expense of their other duties.

Abandoned vehicles were estimated to comprise 12% of the statutory ELV vehicle stock. The information has been aggregated to Government planning region level, with London separated into inner and outer because of the potential differences between the two. For clarity, the figures for each region were proportioned up to 100% to give an estimate for the total number of abandoned vehicles dismantled.

Many local authorities reported a decrease in vehicle storage times, due to the higher number of vehicles being dealt with, and storage capacity being reached. 54% of

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[24] *Enquiries to fleet managers indicated that HGVs and buses are unlikely to be stolen and abandoned. However, HGV trailers were sometimes stolen. For this reason, only data on abandoned passenger cars has been presented.*

Table 7.10 Number of abandoned vehicles recovered by each Government Planning Region in 2000

Region	*Recorded number of vehicles abandoned*	*Percentage response rate from region*	*Estimated total vehicles abandoned*	*Percentage of those reported that were subsequently disposed of*
NE	1,237	70%	1,767	51%
Yorkshire and Humberside	7,311	100%	7,311	35%
East Midlands	7,567	65%	11,642	49%
East	11,066	60%	18,443	40%
SE	25,906	52%	49,819	39%
Inner London	19,739	62%	32,076	51%
Outer London	39,383	65%	60,589	33%
SW	13,995	56%	24,991	48%
West Midlands	10,237	71%	14,418	28%
NW	4,228	69%	6,128	28%
Wales	6,586	68%	9,685	34%
Scotland	4,343	59%	7,361	47%
N Ireland	2,804	100%	2,804	57%
Total:	154,402		247,034	38%

Source: Kollamthodi et al., 2003a.

all the local authorities that were able to answer, and 86% of those in the South East, reported that they do not store any abandoned vehicles. Most of the remainder said that they only store vehicles as long as the road tax is valid. Low storage times were accounted for by a lack of space and the added costs associated with stockpiling vehicles. No reliable figures were provided on the number in storage at any one time. The remainder are returned to the registered owners, or administered by insurance companies.

Used vehicles leaving parc

Used vehicles leaving the parc are defined as those used vehicles that never enter the ELV processing stream. These vehicles may be stolen, legitimately exported or involved in insurance frauds.

When a vehicle is reported stolen, and remains unrecovered, it can be assumed that it is no longer licensed by the last legitimate owner. As a result, it ceases to form part of the vehicle stock. In reality, these vehicles are either broken up for spare parts, have their identity changed, are insurance frauds, or are exported. Actual figures on the proportion of stolen vehicles which reach the ELV processing stream are difficult to determine, however, estimates of stolen vehicles which remain unrecovered can be identified, and assumptions made regarding the fate of these unrecovered vehicles.

The total number of vehicles stolen in the UK is recorded by the Police and collated by the Home Office/DTLR. According to a TRL study 76% of stolen vehicles are recovered in England and Wales, 74% in Scotland and 82% in Northern Ireland (Kollamthodi et al, 2003a). In this study it was assumed that the remaining percentage of stolen vehicles remained unrecovered.

The Motor Salvage Regulation Task Group of the Vehicles (Crime) Act (Crime Reduction, 2004) estimates that of the unrecovered vehicles:

- 40% are broken up for parts;
- 25% have their identity changed;
- 20% are insurance frauds; and
- 15% are exported.

Of those unrecovered vehicles that remain in the UK some will remain part of the vehicle stock, including those that have their identity changed, and some will enter the ELV processing stream. Those that remain part of the vehicle stock do not constitute part of the legitimate vehicle parc.

The proportions entering the ELV processing stream can be estimated as follows:

- 100% of those that are broken for parts will enter the ELV stream (or will undergo a process similar to that of legitimate ELVs);
- 90% of those stolen as insurance frauds will enter the ELV stream (as most insurance frauds involve vehicles at the end of their life, with little or no re-sale value (ABI, personal communication, 2002)).

Therefore the proportions leaving the vehicle parc were estimated in the study as follows:

- 100% of those exported.

- 10% of insurance frauds
- 100% of those vehicles that have had their identity changed.

It was calculated the tonnage of vehicles leaving the vehicle parc in 2000 was 0.1 Mt.

7.6 Special wastes

The Environment Agency's Waste Benchmarking Tool allows the quantities of Special Wastes arising from each industrial activity to be calculated. Special Wastes are wastes defined under the Environmental Protection (Special Waste) Regulations 1996 (as amended) and are broadly defined as any wastes on the European Hazardous Waste List that display one or more of fourteen hazardous properties (for example, toxic, flammable or corrosive). These wastes are more likely than others to be hazardous to the environment or to human health, and therefore are subject to more stringent regulation than other wastes.

The resulting quantities of special waste arisings from the production sector of the motor industry (i.e. companies classified as SIC 34.100 to 34.300, which are *included* in the overall figures quoted for the three motor industry activities described in detail above) are given in Table 7.11.

Special waste from SIC 34 activities represents 21% of the waste from the whole production phase. This is considered to be a significant proportion of the production waste arising, which requires specialist treatment and disposal. Unsurprisingly, the single most significant source of arisings is comprised of oil sludges and oil/ water mixtures, which accounts for 40% of the special waste arisings for SIC 34 activities.

For the wastes arising from ELVs, it is possible to estimate the arisings of special waste for 2000 based on the likely arisings from depollution activities (removal of fluids and batteries has been considered). As Table 7.12 illustrates, the percentage by mass of the total ELV arisings that special waste represents is 2.39%, which is a relatively small proportion of the arisings.

Some of the waste types classified as special waste may be phased out in future, due to increasing regulatory pressure to reduce the hazards associated with certain industry production processes (for example, halogenated compounds, solvent based paints, etc.). Adopting a more

Table 7.11 Special wastes arising from SIC codes 34.1 to 34.3 of the motor industry

Waste type	*Form*	*Arisings tonnes/annum*
Aliphatic hydrocarbon	Liquid	41,196
Aqueous paint	Liquid/sludge	18,189
Cleanable contaminated containers, and other packaging	Solid	16,130
Contaminated vegetable and/or animal matter	Solid	763
Grinding residues	Sludge	75,571
Hydraulic oil and/or fluids	Liquid	1,792
Lubricating and/or fuel oil	Liquid	45,790
Machining/cutting/cooling oils	Liquid	58,844
Mixed/unidentified oil	Liquid	38,585
Not cleanable contaminated containers, and other packaging	Solid	6,915
Oil sludges and/or oil water mixtures	Liquid/sludge	308,605
Organophosphorus compounds	Liquid	7,050
Other halogenated compounds	Liquid	6,958
Other inorganic acids	Liquid	1,071
Other inorganic compounds	Liquid	3,848
Other organic chemical wastes	Liquid	5,327
Other oxygen containing compounds	Liquid	5,562
Paint, varnish and/or lacquers	Liquid	15,056
Sodium hydroxide	Liquid	13,112
Solvent- or oil- based paint	Liquid	74,144
Undrained lead-acid batteries	Mixed	4,851
Used absorbents and/or filter aids	Solid	13,081
Total		762,442
As a percentage of all SIC 34 production waste		24.3%
As a percentage of all motor industry production waste		21.3%

Table 7.12 Estimated mass of special waste arising from ELVs in 2000*

Vehicle type	*Number of ELVs arising in 2000*	*Mass of special waste per ELV (kg)*		*Mass of special waste from ELVsin 2000 (t)*	
		Fluids†	*Batteries*	*Fluids*†	*Batteries*
Cars and taxis	1,902,949	9	12	16,936	22,835
LGVs	207,020	9	20	1,842	4,140
HGVs	34,734	95	70	3,291	2,431
Buses	7,706	95	70	730	539
Motorcycles	118,339	3	6	413	710
Total	2,270,749			23,212	30,657
Mass as a percentage of ELV arisings				1.03%	1.36%
Total mass of special waste as a percentage of ELV arisings					2.39%

* *For cars and LGVs, the figures were used from Kollamthodi et al., 2003a. For HGVs, Buses and Motorcycles, the data used were from the survey for replacement parts (see Section 7.4).*

† *Includes oils, brake fluid and coolant.*

long term perspective in the motor industry to choosing materials will be key in adopting a more proactive stance to reducing hazardous waste arisings. One proposed conceptual framework which is useful for developing such a perspective, known as ‘Design for Recycling’, is presented and discussed in Chapter 8.

8 Trends and influences on the motor industry

8.1 Introduction

The mass balance presented in this report provides a snapshot of resource flows to, from and within the motor industry for 2000. But factors may change in the future affecting the size and nature of these mass flows. Using observed trends, it is possible to predict what some of the pressures and drivers might be for changes in mass flows, and hence resource use. This information has been used to model the effect that such factors could have on the mass balance and therefore on the potential magnitude and type of environmental impacts associated with the motor industry.

The changes in mass flows should also be discussed within a wider context. This should include consideration of what constitutes sustainability in the motor industry and the role of more sustainable resource use within that framework. Where possible, this section comments on trends which may contribute towards sustainability in the motor industry.

Climate change is considered by many environmental policy specialists to be:

> *'one of the most serious environmental threats facing the world today. Its impacts will be felt across the world, as sea level rise threatens the existence of some small island states and puts millions of people at risk. Temperature increases, drought and flooding will affect people's health and way of life, and cause the irreversible loss of many species of plants and animals.'*
>
> (DEFRA, 2003c)

Clearly this is a matter of grave concern and has given rise to political actions to address the influence of human activities on climate change. Actions by governments in developed countries have been ongoing to reduce the emissions of greenhouse gases since the United Nations Conference on Environment and Development (the Earth Summit) was held in 1992. Commitment to continuing such actions was formalised as the Kyoto Protocol to the Climate Change Convention in 1997 (UNFCCC, 1997a and b).

This mass balance study has shown that road transport is responsible for 21% of all CO_2 emissions to air by mass in the UK. Since this gas tends to have a high level of influence on the observed level of climate change due to its abundance (see Box 6.2, Chapter 6), it has been used as an indicator of climate change impacts in this chapter.

The political agenda has led to pressures to reduce CO_2 emissions during the vehicle use, which are likely to lead to further changes in manufacturing and technology in future. Assumptions have been made with regard to what these changes are likely to be, in order to model the effect they will have on mass flows. They include low carbon fuels, alternative manufacturing technologies and vehicle size and shape.

Where the effects on mass flow have been quantified, the assumptions used to calculate both a 'business as usual' (BAU) scenario and a 'projection' scenario reflecting the influence of identified trends are stated explicitly. Where it is not possible to quantify the effects of trends using the mass balance data, a qualitative commentary on the main issues influencing the policy area has been presented. The different future scenarios presented in this chapter are as follows:

1 Introduction of low carbon emission cars and LGVs.

2 Introduction of low-carbon fuelled buses and coaches.

3 Introduction of low carbon fuelled HGVs.

4 Substitution of aluminium for steel.

5 Changes in market share for smaller cars.

6 Effect of increased use of public transport.

Finally, it is recognised that predicting the future is always a rather risky proposition, and this is not what the report has set out to discover in this section. While some of the projection scenarios may not appear either practical or possible at the present time, the report intends to demonstrate what type of benefits may be possible given certain motor industry trends, rather than giving an account of what is considered feasible today. Changing economic, social and environmental conditions will often modify what is deemed practical by each successive generation, as a result of shifting societal priorities.

8.2 Carbon emission reductions

One of the greatest environmental challenges facing the European Union (EU) is meeting its obligations to reduce its production of greenhouse gases (see Box 8.1). The European car industry has entered into a voluntary agreement to reduce carbon emissions from the new car fleet to an average of 140g/km by 2008. The UK Government's contribution to this policy debate entitled 'Powering Future Vehicles: Draft Strategy' (DfT, 2002b) recognised the importance of shifting to a low carbon transport system (see Chapter 6).

Low carbon fuels and alternative power sources

The main reasons for seeking new energy resources are to:

- Increase energy efficiency.

Box 8.1 European greenhouse gas emissions from road transport

The growth in transport greenhouse gas (GHG) emissions is an increasing difficulty for the EU because it makes it more difficult to meet the Kyoto targets for reductions. Transport greenhouse gas emissions increased by 19% between 1990 and 2000, and now account for 20 % of total EU greenhouse gas emissions. CO_2 is the main contributor to transport greenhouse emissions (97%) and road transport is, in turn, the largest contributor to these emissions (92% in 2000). Road transport is one of the two fastest growing contributors to transport CO_2 emissions (aviation is the other). Transport is a small, but rapidly growing source of N_2O emissions, a negative side effect of the increasing use of catalytic converters. By contrast, catalytic converters have also lead to a decrease in CH_4 emissions, which fell by 34% between 1990 and 2000.

EU transport emissions of CO_2 currently account for about 3.5% of global CO_2 emissions. Any action taken to reduce CO_2 emissions will have to involve curbing transport emissions. Passenger cars account for about half the transport-related CO_2 emissions in the EU. In order to reduce the emission of pollutants, car manufacturers must produce fuel-efficient cars. This approach should permit a reduction of almost 30% in CO_2 emissions for new cars coming onto the market.

The EU has already adopted a strategy to reduce CO_2 emissions from passenger cars by improving their fuel economy, with a view to achieving an average CO_2 emission value of 120g/km by 2005 (or 2010 at the latest) for all new cars (Commission communication on a Community strategy to reduce CO_2 emissions from passenger cars and improve fuel economy (COM(95) 689 final)). At present, this strategy consists of an environmental agreement with the automotive industry linked to fiscal measures. The document clearly states that in the opinion of the Commission, other 'measures are required, however, such as vehicle taxation or the establishment of a consumer information scheme. Efforts should also be made to develop alternative, less polluting fuels'.

Sources: EEA, 2002a; EC, 1995.

- Reduce emissions.

However, other issues are also driving the agenda, such as:

- Depletion of fossil fuel resources.
- Minimising the risks associated with dependence on energy supplies for politically unstable countries.
- Increasing prices leading to increased levels of fuel poverty.

Thus energy sources will be a very important issue for the future, with alternative fuels contributing to both decreasing the dependency on finite fossil fuels and CO_2 emission reductions. Alternative fuels, for which claims concerning carbon emission reductions and greater efficiency are made, include:

- Liquefied petroleum gas (LPG).
- Natural gas.
- Hybrids.
- Biofuels.
- Electric vehicles.
- Hydrogen.

It is expected that the marketplace for LPG, a by-product of oil refining but also found naturally, will reach economic sustainability over the next few years.

Compared to petrol, vehicles running on LPG emit around 12% less CO_2 and around 30% less NO_x, HC and CO (LP Gas Association, 2004). According to the Energy Saving Trust[25], natural gas engines are far quieter than diesel engines making them suitable for overnight deliveries and noise sensitive areas[26]. It is likely to remain a viable alternative for depot based vehicles and develop in this niche market.

Hybrid vehicles show very high efficiencies because they employ small engines, which often operate at peak efficiency. Electric storage in the vehicle provides a 'buffer', supplying drive to meet the varying demand for power. It is claimed that life cycle assessments of vehicles powered by electricity (including electricity generation and transmission) suggest they contribute less CO_2 than vehicles using conventional fuels (Energy Saving Trust, 2003).

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[25] *The Energy Saving Trust runs a number of energy efficiency initiatives on behalf of the UK government.*

[26] *See http://www.transportenergy.org.uk/action_cleaner_cng.html for further details.*

Biofuels are alcohols, ethers, esters and organic compounds made from biomass. In theory they are carbon neutral[27] but. their production is energy intensive and requires the use of fertilisers. Biodiesel can be used as a direct substitute for ordinary diesel but this presents some technical difficulties and requires engine modifications. Given these limitations, biofuels present future low carbon opportunities possibly only as a fuel extender, blending up to 5% within conventional diesel. However, this will depend on further development and commercialisation of technology to manufacture liquid fuels from woody resources.

Hydrogen is regarded as a promising alternative in the longer term and could be with us within 20 years. However, it is still unclear as to how to go about creating a hydrogen refuelling infrastructure and what the costs would be. In the shorter term, hybrid vehicles that combine an electric battery with the power and performance of a petrol engine, may offer a more cost effective market option. The crucial issue in terms of whether this technology will be capable of delivering reductions in carbon emissions is how the hydrogen will be made. The reformation of fossil fuels is the cheapest method in the short term, but results in significant carbon emissions. Carbon neutral methods of generating hydrogen proposed as practical ways forward are:

- Reforming fossil fuels with sequestration of CO_2.
- Electrolysis of water using zero carbon energy sources.

Both methods will require significant long term investment and major changes to the energy infrastructure over the next 50 years.

Alternative power sources are likely to remain a focus for research and development activities in future. Some vehicles powered by batteries, fuel cells, hydrogen or compressed air may deliver low emissions at the point of use of the vehicle. However, there is a displacement of emissions due to these energy carriers being reliant on sources earlier in the vehicle life cycle to provide their energy (e.g. power stations). It is important, therefore, to consider environmental benefits over the whole life of the vehicle when choices of technology are made (see Section 8.5).

A variety of vehicles powered by alternative fuels are coming on to the market and are supported by the government's 'TransportEnergy' programme (run by the Energy Saving Trust), where they result in lower emissions and/or better energy efficiency. Box 8.2 provides some case studies of successful fuel switching by organisations, which have resulted in economic benefits and emission reductions. Individuals or organisations who wish to switch to using vehicles powered by alternative fuels may be eligible for a grant from the programme. Power sources featured in the programme include:

- LPG.
- Electricity.
- Natural gas.
- Hybrid vehicles using more than one power source.

The scenarios in this section explore the consequences of current government policies for low carbon vehicles on the energy use and emissions in the motor vehicle industry. Designing vehicles using lighter materials can also assist, since lighter vehicles require less power to achieve the same performance. Interest in alternative, lighter materials used has been discussed in Chapter 4 and is discussed further in Section 8.4.

Energy efficiency can be driven by choices of technology such as energy sources, as described, but a number of practical motoring issues also affect vehicle efficiency (see Box 8.3). Information is available to help motorists and commercial drivers to get the best efficiency from their vehicles, without the need to switch fuels. For example, the Driving Standards Agency publish advice for taxi drivers on efficient driving techniques (Driving Standards Agency, 2002). Box 8.4 describes the Fuel Economy Advisors scheme which exists to impart such advice to haulage operators.

Scenario modelling using resource flow data

In order to look at the effects of the introduction of reduced emission cars and alternative fuels on the data collected, three scenarios have been modelled. The results have been combined and are shown graphically in Figure 8.1.

Scenario 1: Low carbon emission cars and LGVs

Method and assumptions

The current UK car body-type vehicles have an average emissions performance of 174 g/km. The Low Carbon Partnership would like 10% of vehicles by 2012 to produce CO_2 emissions of less than 100 g/km, this percentage climbing to 100% by 2020. In this scenario,

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[27] *Although carbon emissions are released, the net carbon emissions may be considered equal to zero because of concurrent activities to remove carbon emissions from the atmosphere. However, uncertainties in the methods used to quantify the removal of carbon emissions may cause some practical difficulties in accounting for reductions in carbon emissions (see glossary for further details).*

Box 8.2 Some fuel switching case studies

Liquefied Petroleum Gas (LPG): Sutton and East Surrey Water, Redhill

In May 2001, the company introduced 21 bi-fuel vehicles (3 cars and 18 vans running on petrol/ LPG) as part of the fleet of 156 vehicles. Andrew Davidson, the fleet manager, summarised the success of these vehicles by saying: ‘There is no difference between operating vehicles on petrol or LPG. Our use of these vehicles has been a good experience.’

The company has estimated that the fuel cost savings will total a substantial £17,000 for the year (based on a fuel cost differential between petrol at 70 pence and LPG at around 28 pence per litre). The total additional cost for the fleet of 21 bi-fuel vehicles was £21,150 (compared to the petrol version). TransportEnergy PowerShift contributed 75% of this additional cost (£15,860) leaving Sutton & East Surrey Water to pay the remaining cost of £5,290, or an average of £250 per vehicle. Even though the price of LPG has increased slightly over the two years that they have been operating the vehicles, the price differential between LPG and petrol has remained the same. This factor has maintained the operating cost savings.

Compressed Natural Gas (CNG): Warburtons, Bolton

At their Bolton bakery in Lancashire, Warburtons are operating a number of ‘bi-fuel’ CNG large commercial vehicles. The commitment to alternative fuel technology has been matched by investment in their on-site refuelling facility at their Bolton site.

In March 1999 they added two ERF dedicated CNG Cummins-engined large commercial vehicles to their fleet, with the help of a 50% TransportEnergy PowerShift grant. The two vehicles were additions to the existing alternative fuel vehicle fleet in operation since 1998, which consisted of:

- 7 ERF bi-fuel Caterpillar vehicles.

- 3 Leyland DAF bi-fuel Cummins CNG/ diesel rigid vehicles.

The decision to purchase the two additional vehicles was a progression of the original company policy to explore the performance of CNG as a fuel and only the later two vehicles received support from PowerShift. All the vehicles are used for delivering the company’s bread products to stores across the UK. The reliability of vehicles is essential to any business like Warburton’s, which relies on the prompt delivery of perishable goods on a ‘just in time’ basis. In this respect, the CNG vehicles have run as well as their diesel counterparts. The cost of a CNG vehicle is £10,000 to £13,000 (on rigid vehicles) and approximately £20,000 (for tractor units) more than the cost of conventional diesel vehicles.

The capital cost of the on site fuel facility was £500,000. This was supplied by Sulzer, and provides a drive-through station with tank storage. The site has two ‘fast fill’ gas pumps that fill at a similar rate to a diesel pump. Prior to this facility being built the nearest site for refuelling was in Warrington, which proved to be an impractical journey to make from Bolton simply to refuel.

Warburtons calculated that the CNG vehicles’ fuel consumption is about 1.5 miles per kg of CNG compared to 2.5 miles per litre of diesel. The cost per 100 miles travelled on CNG is £21, while the equivalent journey using diesel costs £28 (calculation based on 31.5p/kg for CNG and 70p/litre for diesel).

Sources: TransportEnergy Powershift, 2003a and b.

Box 8.3 Energy efficiency tips for motorists from the Automobile Association

General tips

- Service your car regularly. Servicing maintains engine efficiency and cuts fuel consumption.
- Plan routes to avoid getting lost and driving unnecessary miles.
- Fill up before getting on the motorway. Fuel is generally more expensive at service stations.
- Pack roof racks carefully keeping luggage as low as possible. Wrapping luggage in plastic sheeting can improve fuel economy by 2 per cent and remember to remove the roof rack when you don't need it.
- Try air vents first before opening a window. The airflow might be enough to keep two people comfortable in the front of the car, particularly on a motorway.
- Don't use air-conditioning all the time. Turn it off if doors or windows are still open.
- If you park in the sun, use a windscreen shade. Opening the car as soon as you get back to it will help to cool the interior.
- Open windows before you start the air conditioning. This may lower the temperature a few degrees.
- Pump up the tyres if there are extra passengers or heavy luggage. This will compensate for the extra weight. Check the recommended pressures in the car's handbook.

Before you set off

- Check traffic information.
- Avoid travelling at peak periods. In a tailback, a small car squanders fuel at more than 1p/minute and a medium-sized car loses almost 3p/minute.

Travelling long distance

- Use motorways. Motorway driving can be a considerable money saver, especially when travelling to the coast or tourist destinations.
- Stick to speed limits. Drive gently, avoid unnecessarily hard acceleration, and use the highest gear you can without labouring the engine.
- Avoid driving with under-inflated tyres or a window or sun-roof open. Air-conditioning and carrying extra weight both add to your fuel bill.
- Travel at 70mph on motorways instead of 'going with the flow' at 80–85mph. Fuel costs can go up by as much as 40p for a small car and 36p for a medium car every 10 miles.
- Take notice of electronic motorway signs. Slowing down in bad weather from 70mph to around 50mph, particularly when advised by electronic motorway signs, saves around two pence per mile.

Source: AA, 2003.

the results were used to ascertain the effects of achieving this target using the motor industry CO_2 emissions calculated for 2000. The assumptions required in the calculation were that:

- All the vehicles circulating in 2000 and 90% of the vehicles in 2012 have the same averaged emission rate, i.e. 174 g/km.
- The increase in traffic growth until 2012 was calculated as the increase in the number of vehicle km travelled, using the growth rates sourced from the 1997 National Road Traffic Forecast (DfT, 1997b).
- For the 'Business As Usual' (BAU) calculations, the same year 2000 average emissions of 174 g/km of CO_2 has been used for the increased number of cars and LGVs circulating.

Results

The results show that the CO_2 emissions would be 3.9 Mt less than those found for the BAU scenario by 2012. If all the cars in 2020 had the same 100g/km emission performance, then the amount of CO_2 produced from car transport would be of about 58 Mt against the over 101 Mt of a BAU situation in 2020.

Box 8.4 TRL Fuel Economy Advisors

The Fuel Economy Advisors (FEA) scheme, funded as part of the £100 million Road Haulage Modernisation Fund, is being run by TRL in conjunction with Huddersfield University and Amey plc to give the haulage industry greater access to information about fuel efficiency to help it cut fuel costs.

The FEA scheme is designed to deliver information, practical advice and suggestions for improving fuel efficiency of vehicles and give examples of best practice. Haulage operators across England have been contacted as part of the programme and sent information material such as a newsletter, video and Fuel Saving Tips guide as part of a campaign by the government to increase hauliers' awareness of the benefits of fuel efficiency - and how to achieve them.

The scheme includes an on-site visit to assess the current situation and then providing advice tailored specifically for each individual haulage operator. Drivers, owner-drivers and small or medium-sized operators across England can also benefit from the delivery of free local seminars on specialist themes (fuel monitoring, driver training and aerodynamic) to provide practical advice on how they can boost their fuel efficiency.

Further information on this project is available from http://www.trl.co.uk/fea/

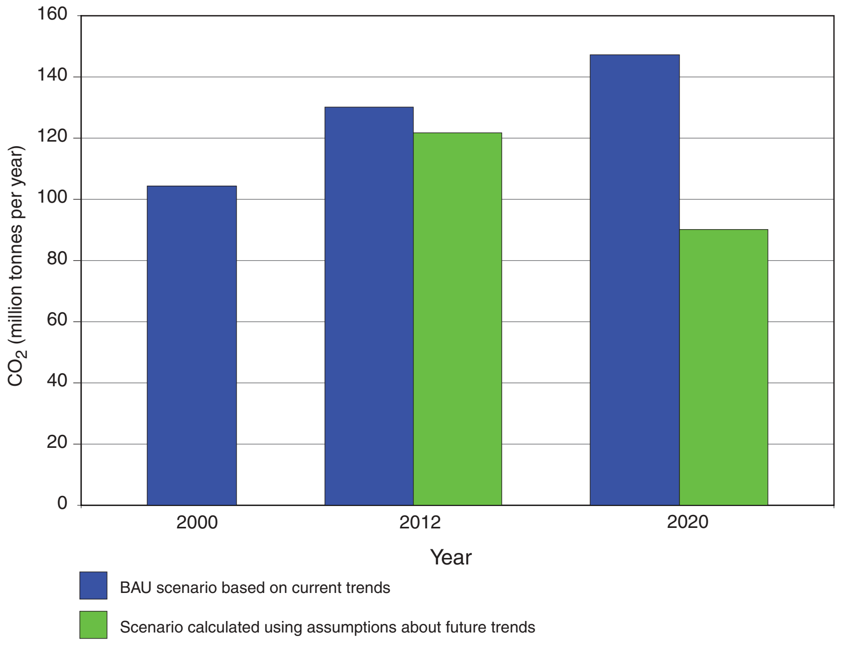

Figure 8.1 The combined effects of assumptions made in scenarios 1-3 on CO_2 emissions data for the motor industry

Scenario 2: Introduction of low-carbon fuelled buses and coaches

Method and assumptions

The Low Carbon Vehicle Partnership is promoting a collaborative programme involving bus manufacturers and operators to shift to vehicles running on fuels with lower carbon emissions. By 2012, the 600 or more buses coming into operation per year will be run on such fuels (i.e. 6% of the fleet). These vehicles are typically defined as having carbon emissions 30% below the current average. In this scenario, the effect of the emission quota from the public service vehicles (PSV) was evaluated, assuming that the introduction of low-fuel vehicles had started from 2000 and in 2020 all the circulating PSV fleet will be low carbon. The assumptions required to investigate this were that:

- All the vehicles circulating in 2000 and 94% of the PSVs in 2012 have the same averaged emission rate, i.e. 334 g/km[28] (NB: g of CO_2 as C).
- The increase in traffic over time has been calculated using the expected increase in vehicle km, using the traffic growth rates from the 1997 National Road Traffic Forecast (DfT, 1997b).
- For the BAU calculations, the same average of 334 g/km has been used for the increased number of PSVs circulating.

Results

The results show that if by 2012 6% of the vehicle fleets will be using fuels with lower carbon emissions, there will be a cut in CO_2 emissions of about 1.7 Mt. If by 2020 all of the buses and coaches have switched over to such fuels, this would mean a contribution of only 5 Mt of CO_2, which contrasts with over 7 Mt for the BAU situation.

Scenario 3: Introduction of low-carbon fuelled HGVs:

Method and assumptions

In order to test the effect of introducing low-carbon fuelled HGVs on CO_2 emissions, it has been assumed that 30% of the HGVs circulating per year coming could be using low carbon fuels by 2012 (i.e. 30% of vehicles would have emission rates 30% below current average carbon emissions). The emissions from the HGV fleet were evaluated, assuming that the introduction of low-fuel vehicles had started from 2000 and in 2020 all the circulating HGV fleet will be low carbon. The results were then compared with a BAU scenario. The assumptions made to test this were that:

- All the vehicles circulating in 2000 and 70% of the HGVs in 2012 have the same averaged emission rate (i.e. 156 and 315 g/km of CO_2 as C per rigid and articulated HGVs respectively).
- The traffic increase is calculated as increase of vehicle km, using the growth rates sourced from the 1997 National Road Traffic Forecast (DfT, 1997b).
- For the BAU calculations, the same emissions averages as for the 2000 HGV fleet have been used for all additional HGVs circulating.

Results

The results show that if by 2012, 30% of the vehicle fleet will be using low-carbon fuels, there will be a cut in CO_2 emissions of about 3 Mt. If by 2020 all the HGV fleet was fuelled by low-carbon fuels, then there would be a cut in emissions of about 11.5 Mt of CO_2

Discussion of the results obtained from scenarios 1 to 3

The combined measures described in scenarios 1 to 3 would allow in 2020 for a cut in CO_2 emissions of about 56.9 Mt in comparison with BAU. This compares with figures for the whole motor industry in 2000 of 559 Mt of emissions, representing a reduction of about 10% on the 2000 figure. Clearly, this is significant.

However, within the EU obligation under the Kyoto Protocol, the UK has a target of reducing six greenhouse gas emissions to 12.5% below the 1990 level in the first commitment period (2008–2012). In terms of CO_2 emissions only, levels are forecast to be reduced by 8.4% below 1990 levels by 2010, and by 4.4% in 2020. This is equivalent to a reduction to 160.7 Mt (as carbon) in 2020 from 168.0 Mt in 1990 (DETR, 2000b). This is equivalent to requiring reductions in emissions from 616.0 Mt to 589.2 Mt as CO_2 between 1990 and 2020, a reduction of 26.8 Mt. Clearly, if the combined measures described in scenarios 1 to 3 were implemented in full, they would allow the UK to meet its obligations in respect of reducing CO_2 emissions and achieve additional reductions of 30.1 Mt.

Although the scenarios have been evaluated as an illustrative exercise only, they demonstrate the order of magnitude of emissions savings that may be possible by achieving higher market penetration for low carbon vehicles. It is likely that targets for reducing greenhouse

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[28] *Based on data sourced from NAEI (2003), 'The UK Emission Factor Database'. The mean value for carbon emissions was based on values quoted for buses and coaches in 2000 for rural, urban and motorway driving.*

gas emissions will be more demanding in future, with the recent RCEP report on energy urging targets of 60% reductions by 2050 to be set on 1990 levels. It is likely that other measures will also be required if such targets are to be attained (RCEP, 2000).

8.3 Improving urban air quality by reducing harmful emissions from vehicle use

Emissions requiring reductions

A number of key air emissions identified as having a significant input from vehicle use have been identified (NETCEN, 2003a). The emissions to air discussed in this section have been selected on the basis that:

- Their concentration in the atmosphere is largely affected by the use of vehicles in urban areas.
- They can potentially have adverse effects on urban air quality.
- They have been targeted for reductions by new technological developments in vehicles, because of the hazards posed by their release into the atmosphere.

1,3-Butadiene and benzene are both volatile organic compounds (VOCs) and are present in the air in the UK principally as a result of the distribution and combustion of motor fuel (petrol and diesel). VOCs are released in vehicle exhaust gases either as unburned fuels or as combustion products and are also emitted by the evaporation of solvents and motor fuels. Their possible health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.

Carbon monoxide (CO) arises from incomplete fuel-combustion. In most combustion reactions, oxygen concentrations are relatively high and any CO produced is quickly oxidised to CO_2. However, this is not the case when motor vehicles are idling or the vehicles are slowing down. Conditions of congestion in urban areas tend to lead to queuing traffic, where vehicles often idle or accelerate and decelerate rapidly for long periods. Consequently, motor vehicles are the major point source of CO pollution in the UK. This is of concern mainly because of its effect on human health and its role in tropospheric ozone formation. It leads to a decreased uptake of oxygen by the lungs and can lead to a range of symptoms as the concentration increases.

Nitrogen oxides refers to nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x. The main source is road traffic (petrol and diesel vehicles) and the heaviest concentrations are found in congested, urban areas. These gases can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure may cause increased incidence of acute respiratory illness in children. NO_x emissions are acidic, and contribute towards amplifying the natural process of acidification, which in extreme forms causes ‘acid rain’. Acid rain can have harmful impacts on the environment. It affects freshwater lakes and the wildlife that depend upon them. It also affects trees by harming leaves and soil and it damages buildings made of limestone and marble.

Particulates (PM) can vary widely in its physical and chemical composition, source and particle size. Primary PM are those emitted directly to the atmosphere while secondary particulates are those formed by reactions involving other pollutants. In the urban environment, most secondary PM occurs as sulphates and nitrates formed in reactions involving sulphur dioxide and nitrogen oxides. PM_{10} particles cause the most concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. The principal source of airborne PM_{10} is road traffic emissions, particularly from diesel vehicles. The fine particles can be carried deep into the lungs where they can cause inflammation. In addition, they may carry surface-adsorbed carcinogenic compounds into the lungs.

Current and planned motor industry activities to reduce these emissions

The TransportEnergy CleanUp campaign is aimed at improving air quality in the UK by reducing emissions from diesel vehicles by offering government grants and assistance to fit emissions reduction technologies[29]. In Box 6.5 (Chapter 6) the greater use of particulate traps was discussed as one mechanism for removing the material from exhaust emissions in large vehicles such as buses. Other currently available technologies include:

- *Oxidation catalysts* are fitted to all new diesel passenger cars and car based vans in Western Europe. These devices will also be fitted to other LGVs from now on. Emissions reductions of up to 90% for CO, 90% for hydrocarbons (HC) and 25% for PM may be expected.
- *Re-engining buses*. Buses usually require a new engine at some time in their operational life. Significant reductions in both NO_x and PM are normally realised when an old engine is replaced by new technology. Reliability is also likely to be better. Euro 3 engines are now available which deliver over 35% NO_x and 70% PM reductions on a pre-Euro engine (more if a particulate trap is fitted).

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[29] *See http://www.cleanup.org.uk/ for further details.*

- *Conversion to LPG or natural gas* can have a number of benefits. Converting a Euro I light duty diesel engine to LPG can reduce emissions of NO_x by 85% and PM by 90%. The engine will also be considerably quieter and there will be less vibration. Natural gas is mainly comprised of CH_4. It can significantly reduce output of NO_x and PM compared with diesel in certain applications. An additional advantage over the diesel engine is the very low engine combustion noise. This feature makes natural gas particularly suitable for vehicles operating in noise-sensitive locations (refuse vehicles, night time delivery vehicles).

- *Exhaust gas recirculation (EGR)* as a retrofit on existing heavy duty engines, has been fitted to 200 buses in Stockholm, Sweden and has been shown to provide around 50% NO_x reduction. Since a particulate trap is also fitted, the usual emissions reduction benefits of that device are also gained (95% PM, 90% CO and 90% HC).

- *Selective catalytic reduction (SCR)* uses ammonia as the agent to reduce NO_x emissions. Trials have shown that this can reduce NO_x by over 70%, with a potential of up to 90% in heavy duty vehicles. SCR catalysts only reduce NO_x emissions from exhausts. For this reason, an oxidation catalyst (see above) is usually added to reduce emissions of CO and HC and to minimise the risk of ammonia emissions to the atmosphere.

It can be expected that there will be continued innovation in either preventing the creation of or removal of harmful exhaust emissions from vehicle use in future. This is to be welcomed and will contribute to better air quality, particularly in areas of congestion. However, emissions reductions may also be achieved by reducing the number of journeys made by road in the UK. This is discussed in Section 8.7.

8.4 Vehicle design

Increased use of aluminium

The weight of a vehicle, and therefore fuel consumption, can be substantially reduced by replacing steel parts with others, manufactured from lighter weight materials such as aluminium or composite materials. Composite materials are those that are made from reinforced fibres added to a matrix of much lower mechanical strength material. However, the carbon fibre that is often used is not recyclable and its replacement with other materials such as hemp may be considered in the future.

Aluminium body panels already replace steel in some vehicles. However, aluminium is much more difficult to weld. For this reason, the technologies involved in manufacturing cars with aluminium body panels are much more energy intensive. An increase in the use of aluminium in car manufacture has been modelled to determine the total effect on environmental impacts. This has not taken into account energy demand during manufacturing.

The development of new materials could be limited in the future by improvements in the properties of traditional materials. For example, the production of high strength, low alloy steels for vehicle shells. There is also some concern as to whether the ELV Directive[30] requirements on recycling would lead to manufacturers moving away from considering lightweight body panels. For example, the plastic body panels used by Renault in the Espace have now been replaced with steel panels. This is thought to be because steel can be recycled more easily than plastic and also weighs much more, so in terms of percentage by weight this boosts the recyclability of the vehicle. This suggests that in policy terms, there may be trade-offs to consider between the desirability of making vehicles more recyclable against the energy and emissions reductions associated with lighter vehicles.

Scenario 4: Substitution of aluminium for steel

Method and assumptions

According to the Aluminium Association[31], it is possible to substitute 1 kg of aluminium for 2 kg of ferrous metals in new cars, which would allow for a considerable reduction in their mass without compromising important features such as safety. This reduced weight would also lead to a reduction in fuel consumption and emissions to air. However, the production of aluminium is noted as a relatively energy intensive process.

The average mass of a new car is assumed to be 1,035 kg and comprised of 68% ferrous metal in 2000 (see Chapter 4). This equates to 703.8 kg of ferrous metal per vehicle. Assuming that a total of 500kg of ferrous metal could be substituted by 250kg of aluminium in new cars entering the vehicle parc between 2000 and 2020, modelling was carried out to ascertain the effects on energy use and emissions. The assumptions required to assess these effects were:

- The model calculates an aluminium-steel substitution in two steps, with the first in 2012 (replacement of 250kg ferrous by 125kg aluminium) and the second in 2020 (replacement of 500kg ferrous by 250kg aluminium)[31].

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[30] *Directive 2000/53/EC.*

[31] *See http://www.autoaluminum.org/environ.htm for further details of assumptions used to arrive at factors used in calculations.*

- CO_2 emission factor of 0.156 and 0.122 g/kg for petrol and diesel cars respectively has been used for calculating the emissions for cars in the study[32].

- In all calculations, an increase in car mass of about 20kg has been assumed per year. This total mass of vehicles in the car parc (both in the lightweight and business as usual scenarios) is calculated from a baseline assumption that the average mass of a car in use in 2000 was 1035 kg.

Results

The results suggest that the introduction of aluminium in new cars would allow a saving of up to 17% of the total emissions produced per km by the cars in use in 2020 (a reduction from 6.3 kt/ km to 5.2 kt/ km). This is illustrated in Figure 8.2.

However, the CO_2 emitted and the energy used for producing the necessary quantities of aluminium produced could increase significantly with respect to the business as usual scenario, given that steel production is a generally lower energy intensity process which releases less CO_2. However, this was not investigated within the scope of this scenario.

Although the use of alternative materials such as aluminium seems attractive in principle, the energy and emissions used over the whole life cycle might in fact increase rather than decrease, despite the finished vehicle being lighter. These issues would need to be studied in more depth as part of any implementation of integrated product policy for the industry from a life cycle perspective. This is discussed further in Section 8.5.

Design changes and energy efficiency

Energy consumption from the transport sector is increasing at European level (see Box 8.5). At high speeds, aerodynamic resistance is responsible for most of a vehicle's fuel use and there has been much interest in reducing this resistance to as low a level as possible. Aerodynamic resistance depends greatly on vehicle design factors such as:

- The shape of the front of the vehicle.
- The angle of bonnet slope.
- The angle of the front of the vehicle and rear windscreen inclination.
- The external shape of the roof.
- The shape of the vehicle rear.
- The roundness of the edges.
- Vehicle air ducts.

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[32] *Based on carbon emission data for cars sourced from NAEI (2003), 'The UK Emission Factor Database'.*

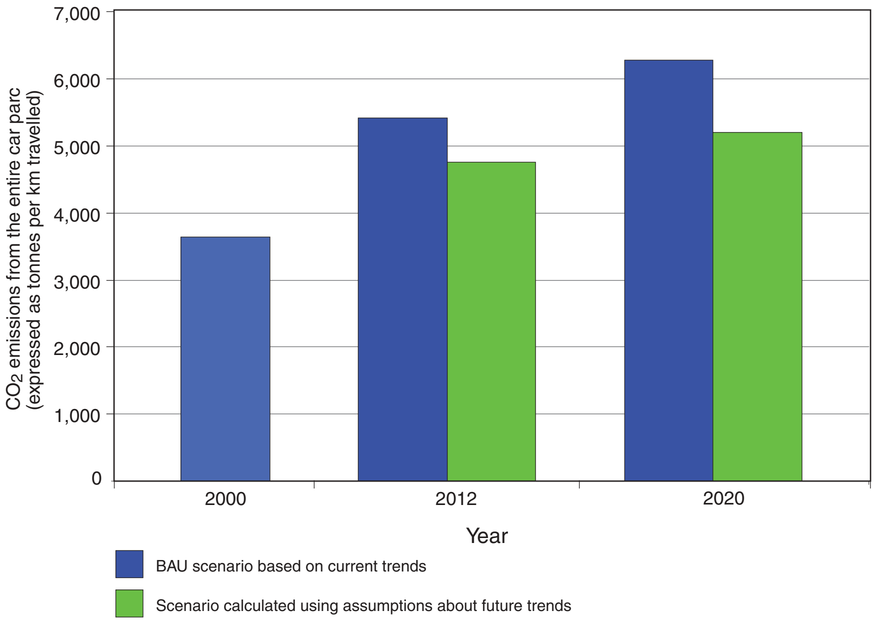


Figure 8.2 Effects of Scenario 4 (substitution of aluminium for steel in vehicles to reduce mass) on CO_2 emissions from car exhausts during use

Box 8.5 European energy consumption by road transport

Transport energy consumption increased by 21% between 1990 and 1999. It is the biggest energy-consuming sector in Europe, being responsible for about 30–35 % of total energy consumption in 1999. The road transport sector is the largest consumer of energy, accounting for around 72 % of transport energy consumption.

Source: EEA, 2002b.

Box 8.6 describes how aerodynamic properties of trucks can affect their efficiency.

Market trends suggest that changes in vehicle design aimed at improvements in fuel efficiency may be countered by a number of factors. These factors include the comparatively affordable cost of fuel and the vehicle weight increases resulting from the extra comfort and safety features that are becoming more common.

For example, the physical size (and mass) of the average passenger car has significantly increased over the past thirty years in response to customer preference for improved interior comfort and space. New passenger car types such as Multi Purpose Vehicles (MPVs) and the popularity of four-wheel drive vehicles have also played a part in the higher average weight. Additionally, vehicle manufacturers have also increased the amount of equipment fitted to cars - for example equipment such as satellite navigation systems, CD players, and electric seats is now not uncommon, and has had the effect of increasing average weights. Finally, in-car crash protection requirements have led to the almost universal introduction of airbags and side-impact protection bars, as well as forcing manufacturers to design car bodyshells with much higher levels of structural reinforcement, leading to heavier bodyshells.

The trend towards more comfort and safety features means that there may be a need for vehicles to change from a 14 volt to a 42 volt electrical system (using a 12 volt or 36 volt battery respectively) in order to power the extra equipment. This highlights a gradually increasing demand for energy for auxiliary accessories in vehicles. This will in part address the problems experienced in respect of promoting the reduction of vehicle mass while accommodating more electrical equipment, since the current 14-volt systems will be unable to provide more power without substantial increases in mass. This is because larger batteries and thicker wires would be required to achieve the desired power. A higher-voltage system may deliver more useful power at either the same or a lower amperage. However, it is likely that changing the electrical system to 42 volts will require changing virtually every electrical function in a car, from the distribution system to connectors and semi-conductors. For this reason, it is not expected that this change will be possible before 2007 at the earliest (Auto Industry, 2002).

Changes in market segmentation

A number of classes are used to describe the market segmentation of the passenger car market (see Table 8.1). These classes range from A to I and describe the size, likely use of the vehicle and its intended market. According to SMMT (2003a), it is likely that in future there will be an increase in class B and C cars sold (as a percentage of total sales of new vehicles), which should reduce the mass of the vehicle parc. However, these vehicles are also expected to continue current trends of tending to increase in size. For example the current Ford Fiesta is much larger than previous model variants. It is also thought that there will be more market segmentation but smaller volumes of each model type sold. This will increase the need to establish common platforms and common components for the production of different vehicles. This should allow for more flexible manufacturing processes and increase the possibility of reusing and recycling vehicle components. This is already occurring at some manufacturing sites. For example, it is now possible to manufacture 5 different variants of the Ford Fiesta on the same assembly line (Ford, 2002).

Table 8.1 Car class definitions in common use

Car class	*Examples of cars in class*
A-Mini	Honda Jazz, MCC Smart
B-Supermini	Rover25, Peugeot 206
C-Lower medium	Ford Focus, Fiat Stilo
D-Upper medium	Alfa Romeo 156, Renault Laguna
E- Executive	Audi A6, BMW 5 Series
F-Luxury saloon	Bentley Arnage, Mercedes S Class
G- Specialist sports	Porsche 911, Audi TT
H-Dual purpose	Nissan X Trail, Land Rover Discovery
I-MPV	Toyota Picnic, Seat Alhambra

Source: SMMT, 2002.

Scenario 5: Changes in the market share for smaller cars (Class B and C)

Method and assumptions

SMMT (2003a) has found that ‘in addition to technical improvements in cars, the market has seen a shift toward smaller vehicles in recent years’. It is believed that class B & C cars will increase their market share by 25% by 2012, displacing larger cars from other vehicle classes.

Box 8.6 Aerodynamic drag for trucks

Aerodynamic drag accounts for a significant proportion of the fuel consumed by a truck in use. The measurement used to indicate the magnitude of aerodynamic drag experienced is known as the wind averaged drag coefficient, Cd_{ave}. Trucks in use with a large Cd_{ave} value experience high aerodynamic drag, whereas trucks with a small Cd_{ave} value experience low aerodynamic drag.

The percentage reduction in fuel consumption which it is possible to achieve by reducing aerodynamic drag depends on the type of vehicle considered and its design. For trucks, this ranges from about 23% for a rigid truck to about 20% for articulated truck type. For example, a vehicle covering 160,000 km per annum consuming 35 litres of fuel every 100 km will use 56,800 litres of fuel annually. Reducing the aerodynamic drag can lower this fuel consumption by 6 to 12%, which provides cost savings and environmental benefits.

The graph below shows the relationship between reduction of drag coefficient and fuel savings for rigid and articulated trucks, using the conditions outlined in the following table.

Conditions considered for investigating the relationship between drag coefficient and fuel savings

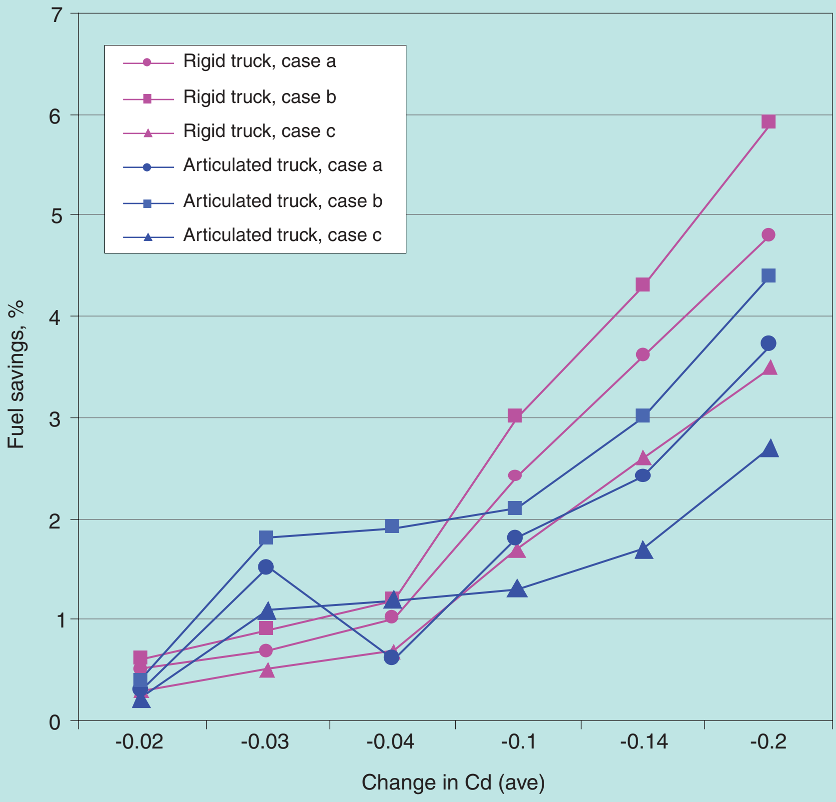
Parameters used in calculations	*Case a*	*Case b*	*Case c*
Vehicle mass (tonnes)			
Rigid	17	10	17
Articulated	40	32	40
Route composition driven by the truck (%)			
90 km/h	40	40	30
Undulating motorway	20	20	20
Typical A/B road	20	20	20
Mountainous	5	5	5
Urban	15	15	25
Distance driven per year (km)			
	160000	160000	160000
Fuel consumption of truck (litres /km)			
Rigid	0.28	0.28	0.28
Articulated	0.40	0.40	0.40
Wind averaged drag coefficient for truck, Cd_{ave}			
Rigid	0.7	0.7	0.7
Articulated	0.85	0.85	0.85

The graph illustrates the maximum potential fuel savings if the assumptions in the table are used in calculations and the maximum drag coefficient reduction is assumed. The annual CO_2 emission reductions that would accompany these reductions in fuel use are significant. For example, if for Case b the maximum drag coefficient reduction is assumed, the calculated annual CO_2 emissions would be:

- For the rigid truck, 109 tonnes, contrasting with 116 tonnes with normal drag coefficient.
- For the articulated truck, 158 tonnes contrasting with 166 tonnes without aerodynamic improvements.

Continued ....

Box 8.6 (Continued) Aerodynamic drag for trucks



Source: Energy Efficiency Best Practice Programme (2001)

Figure 8.3 Graph to illustrate the potential fuel savings from reduction of drag coefficient in rigid and articulated trucks

This scenario has attempted to find out what change in emissions this would result in, based on the mass balance data available for 2000. The assumptions required were that:

- All the vehicles circulating in 2000 have been split in classes as from information on market shares from the SMMT.
- For each class, an average emission rate taken from technical specifications, has been used to calculate the emissions in 2000.
- For the 2012 scenario, two alternatives have been evaluated In the first, the emission rates have been kept at 2000 levels for the new distribution of classes. In the second, an improvement on emission rates have been assumed (30% lower for each class).

Results

The results (see Figure 8.4) demonstrate that a switch to smaller cars would involve a reduction in CO_2 emissions of 1.8 Mt. However, if the emissions of all the cars by then would have improved, then the difference with respect to a BAU scenario (i.e. having the same market share and emissions as 2000) would be approximately 27 Mt of CO_2.

8.5 Integrated product policies

Integrated Product Policy (IPP) is a current EU environmental initiative (Commission of the EC, 2001). IPP seeks to minimise environmental degradation by looking at all phases of a product's life cycle and taking action where it is most effective.

The life cycle of a product is often long and complicated. It covers all the areas from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to their eventual disposal as waste. At the same time it also involves many different actors such as designers, manufacturers, marketing people, retailers and consumers. IPP attempts to stimulate each part of these individual phases to improve their environmental performance.

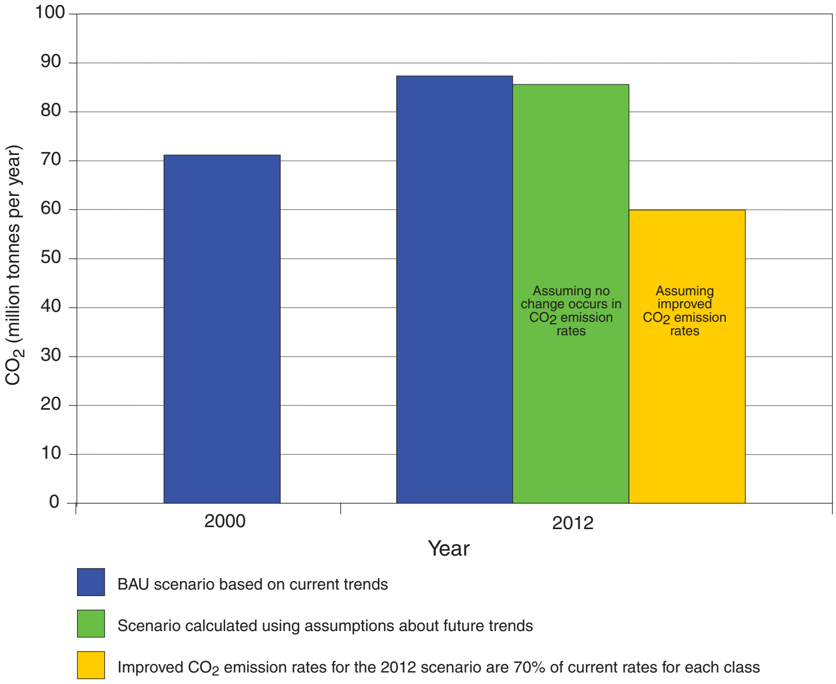


Figure 8.4 Effects of changes in market share for small cars on CO_2 emissions

With so many different products and actors, it is not possible to envisage the development of one simple policy measure to be applied to all situations. Instead there are a variety of tools (either voluntary or mandatory) that can be used to achieve this objective. This includes the policy tools listed in Table 8.2. The right balances between these approaches and some objectives for the policy are currently being addressed at European level, following the publication of the Green Paper on Integrated Product Policy COM (2001) 68 final (Commission of the EC, 2001; 2003).

IPP and other policy approaches in the UK motor industry

Integrated product policies for the UK motor industry would need to consider a range of different measures, such as those in Table 8.2. These measures involve a mixture of voluntary and mandatory policy tools. In the short term, it is likely that greater emphasis will be placed on fulfilling statutory requirements by both policy makers and the industry. However it is not known at present how the IPP initiative will affect policy and practice in the UK. It is likely to be of increasing practical importance to examine the competing requirements of the different statutory and non-statutory policy options and tools available to ensure that progress can be made to reduce environmental impacts arising from a life cycle perspective.

For example, the ELV Directive encourages greater levels of material recycling. However, it may be more beneficial from a life cycle perspective to avoid waste production (by extending the life of vehicles and components) and to make vehicles lighter, to reduce energy use and carbon emissions[33]. The Directive's recycling targets (set as a percentage by weight) may have the potential to conflict with the use of lighter materials in new cars in future. This may occur because the most recyclable and heaviest material in statutory ELVs is steel, and substitutions for lighter materials reduce the percentage mass which can be recovered given current markets for recyclate and the available recycling infrastructure (BMW, 2003).

It is not possible to speculate on the way in which such apparently competing policies will be addressed in future industry practices. For this reason, discussion in this section will focus on the requisite policy considerations from a life cycle perspective to effect greater recovery of materials from ELV arisings in the UK. The materials available vary, as does the reprocessing infrastructure to recover the materials. Current and future legislation is focussed on increasing the masses of ELV material recovered. This raises a number of issues which will need to be addressed, in order to achieve this objective.

First of all, the processing and reprocessing capacity would need to be adequate to cope with the expected masses of ELVs arising. For statutory ELVs, there is not enough data at present to discern any overall annual trend in the masses of ELVs arising in the UK (see

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[33] *To the knowledge of the project team, there is no definitive evidence in the public domain to either confirm or refute this at present.*

Table 8.2 Summary of the main instruments and actions required for implementation of the EU IPP

Instrument
- Proposed action

Economic instruments
- Identify price elements which prevent a more ready take up of greener products in the market.
- Investigate options for differentiated taxation (e.g. reduced VAT rate for eco-labelled products within New VAT Strategy) etc.

Producer responsibility
- Extend the concept to further areas of Community legislation.
- Encourage Member State initiatives.

Eco-labels
- Extend to more products.
- More public funding for marketing and funding.
- Review the Community eco-labelling strategy.
- Use eco-label criteria for other applications (e.g. procurement, benchmarking, eco-funds, indicators, essential requirements).

Environmental declarations
- Prepare monitoring of the use of environmental self-declared claims.
- Set up a framework to support declarations in line with ISO Type III.

Public procurement
- Adopt an Interpretative Communication on Public Procurement and the Environment.
- Draw up a Handbook on Green Public Procurement (GPP).
- Co-ordinate and facilitate an information exchange on GPP.
- Green the Commission's own public procurement.

Product information
- Link existing information on life cycle impacts of products.
- Support the development and dissemination of easily applicable tools to evaluate life cycle impacts of products (in particular for SMEs) and to improve the information flow along the product chain.
- Host workshops on the most-efficient ways to achieve these goals.
- Investigate the potential for schemes to oblige/encourage producers to provide key information on environmental product characteristics.

Eco-design guidelines
- Encourage the elaboration, dissemination and application of such guidelines.

Standards
- Support the development of standards on the environmental design.
- Find ways and means in co-operation with all stakeholders to achieve that 'environmental soundness' will be systematically associated with all European standards.

New approach
- Review the potential of New Approach legislation to encourage greener product design.
- Ensure an optimal use of the New Approach in legislation such as the planned Directive on Electrical and Electronic Equipment.

Product panels
- Develop the framework for product panels.
- Launch one or two pilot projects in 2001.

Supportiveinstruments
- Make the link with EMAS.
- Ensure that green product innovation is a key part of Community.
- Research and development programmes (FP5, Growth Program; FP6).
- Put a focus of the LIFE programme on the greening of products.
- Investigate the potential of environmental reporting.

Source: Adapted from Annex 3 to Green Paper on Integrated Product Policy, COM(2001) 68 final.

Table 8.3), but the masses are expected to rise over time because of the trend for the unit weight of cars and LGVs to increase since 1990[34]. Since statutory ELVs account for 89% of the UK ELV arisings by weight in 2000, it can be expected that the unit weight for such vehicles will largely influence the mass of materials available.

Table 8.3 UK statutory ELV arisings in 2000 and 2003

	Total weight of ELV arisings (Tonnes)	
	2000	*2003*
All ELVs	1,983,340	1,932,769

Source: Kollamthodi et al., 2003a.

The UK processing and reprocessing capacity available at the moment is adequate for current ELV arisings and to achieve a level of recycling equivalent to between 75 and 80% of the mass of ELV arisings[35]. However, an expansion in capacity is likely to be required to increase the level of recovery to 95% (85% by recycling) by 2015, as required in the ELV Directive. There are two reasons for this:

1. The simple increase in masses processed and reprocessed, which would mean that even recycling the same proportion of material in future will necessarily involve larger masses of material.

2. The requirement to recover materials which until now have been considered too difficult to recover, either because of technical difficulties or lack of economic incentive.

A recent study has quantified current recycling rates for each material arising from statutory ELVs. It was concluded that while the recycling of metallic materials was already very high, it was likely that there would need to be a significant increase in capacity to recover non-metallic materials in order to meet the ELV Directive targets (Kollamthodi *et al.*, 2003a. Kollamthodi *et al.*, 2003b; see Chapter 7, Section 7.5 for presentation of these figures).

The main issues to be examined in order to create the policy conditions to achieve higher rates of reuse, recycling and recovery will include the following:

- Solving the technical problems associated with recovery for certain waste streams (e.g. separation of plastics).

- Attracting investment to expand the recovery sector.

- Finding new markets for recovered materials, especially those for which there is little recovery at present (e.g. plastics, glass, textiles).

Some of the possible benefits of increased recovery in the industry will be related to better resource productivity and can be listed as:

- Reducing the need for landfill capacity.

- Reduced reliance on material extraction (as a result of reusing materials rather than requiring virgin materials).

However, issues such as reduced energy requirements and emissions in comparison with current practice would need to be examined from a life cycle perspective (i.e. from ‘cradle to grave’) to confirm that the expected benefits would be realised. For example, if a market for the recycling of automotive plastics developed in India or China, the increases in demand for transportation to and from the UK would be expected to have a large influence on the magnitude of energy consumption and emissions generated by the activity, in comparison with the current arrangements. This demonstrates that it is not self-evident that a higher level of recycling *always* results in an increase in environmental benefits from a life cycle perspective, and that these benefits must also be balanced with other social and economic benefits in order to generate more sustainable solutions. It is recommended that further research be conducted on such market expansion to support environmentally sound policy development.

These measures deal with the need to recover ELV arisings in the short term. However, from a technical perspective, there has been renewed interest within the automotive

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[34] *From DTLR’s Transport Statistics publication ‘Vehicle Licensing Statistics’, it has been estimated that the average age of a natural ELV is 12.8 years, whilst the average for a premature ELV is 6.7 years. Using these figures, for the year 2000, an average natural ELV would have originally been registered in 1987, whilst an average premature ELV would have been first registered in 1993. Estimates of the masses of ELVs arising were arrived at by referring to the lists of the best selling passenger cars for these two years and masses were then collated from past editions of ‘What Car?’ magazine and ‘Autocar’ magazine. During the 1980s and 1990s, the Society of Motor Manufacturers and Traders (SMMT) regularly supplied these lists to the major motoring magazines. The masses observed for the best selling cars over this period showed a clear upward trend, as both the size and weight of passenger cars and LGVs increased.*

[35] *Various figures are quoted in the literature. ACORD (2000) estimated that 80% of the mass of each car is routinely recycled. A recent report using a mass balance approach (Kollamthodi et al, 2003) estimated that 76.87% of the mass of statutory ELVs in the UK was recovered in 2000. Industry estimates put the figure closer to 75%, based on full recovery of the metal content of a vehicle only (e.g. ELV directive text). However, these estimates only cover 89% of the ELV arisings, as they do not account for variations in recovery from HGVs, buses and motorcycles.*

industry in attempting to eliminate mixed material arisings at source using 'Design for Recycling' approaches in the industry (see Box 8.7). This is an attempt to maximise the chances that resource productivity can be improved in the longer term. A current example is the attempt by Ford to standardise the type of plastics used, in order to simplify the recovery process when cars reach the end of their useful lives and the material requires collection and reuse. The Ford Model U Concept also embraces other 'Design for Recycling' guidelines (see Box 4.2 (Chapter 4) and Box 8.7). Measures such as limiting the number of plastics used in dashboards could also increase recyclability (see Box 8.7). The 'PRoVE' project (Plastic Reprocessing Validation Exercise), undertaken by the British Plastics Federation (BPF, 2003), aims to produce a generic standard for recycled plastic. This will lead to greater recycling of parts to manufacture new components. This will be achieved by overcoming the barrier of demands that recycled plastics meet the same quality standards as

Box 8.7 Design for recycling

It is often difficult today to deal effectively in environmental terms with automotive components that were originally designed without any consideration of their ability to be recycled in the future. As a consequence of this lack of forethought, materials can be difficult to reuse and may be hard to separate. A highly relevant example is the difficulty in characterising the automotive plastic material stream and consequently reusing components or materials from the stream in high specification applications. For this reason, an element of design requires consideration which is often neglected: the design of automotive parts to maximise the opportunity to recycle materials in the future. This is known as 'Design for Recycling', and has two components:

- Making strategic decisions about the type of material recycling systems to be encouraged in the motor industry (closed-loop or open-loop).
- Choosing materials wisely in new product design, since they become part of the material recycling system later.

Types of material recycling system

It is possible to characterise material recycling systems in two ways. Closed-loop recycling involves the reuse of materials to make the same product over and over again, as illustrated in Figure 8.5. An example would be the recycling of automotive plastic back into the production of new cars. The alternative is open-loop recycling, which reuses materials to produce different products (see Figure 8.6). An example here would be reusing tyre rubber crumb as a binder in road surfacing. The preferred mode of recycling will depend on the particular material stream studied, but in general, closed-loop recycling is preferable. This is mainly due to having better control of issues such as quality control, because the material characteristics are more easily defined and controlled. It also maximises the probability that the materials can be reused again in the same application in future.

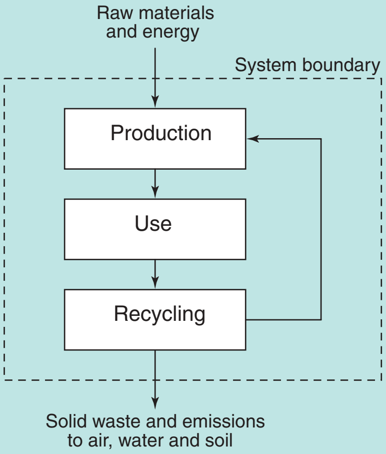

Figure 8.5 Simplified diagram to illustrate the life cycle of a product involving closed loop recycling

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Box 8.7 (Continued) Design for recycling

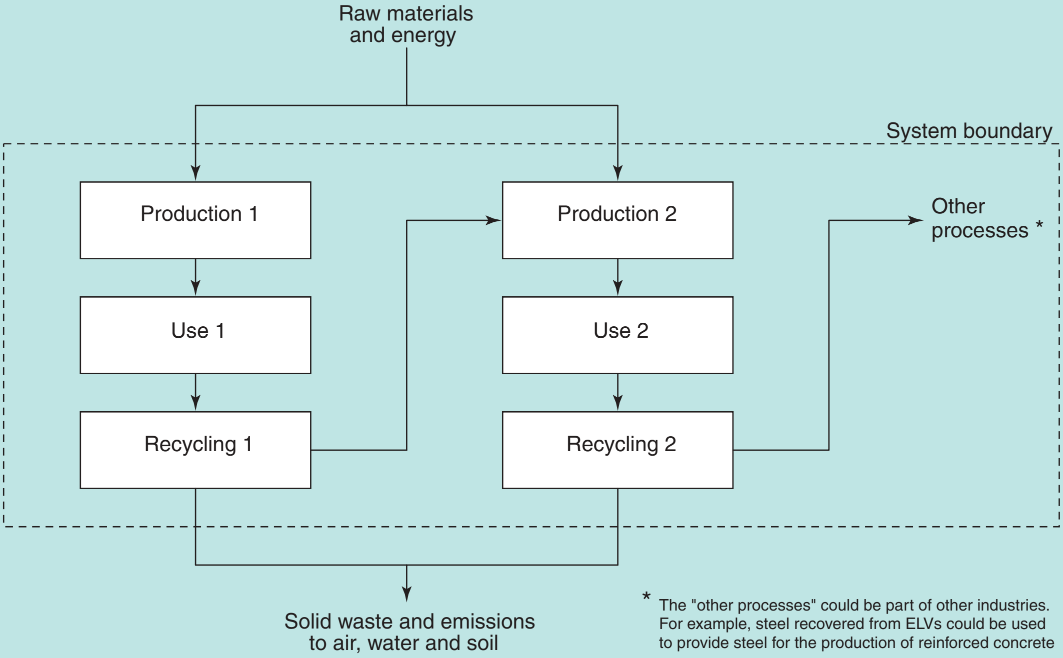

Figure 8.6 Simplified diagram to illustrate the life cycle of a product involving open loop recycling

Graedel and Allenby (1998: pp. 77-154) have proposed a number of simple rules to follow, in order that the potential for recycling in future can be maximised in industrial systems. Using these principles, it is possible to make some recommendations for maximising the potential to recycle materials used in the motor industry:

- *Minimise the use of materials.* Advanced materials with better structural characteristics may allow smaller amounts of material to be used. Better design guidance may allow less materials to be used to achieve the required stiffness and load bearing characteristics.
- *Minimise the materials diversity* (i.e. the number and type of materials used). Material selection should be optimised across the global motor industry to limit the variety of materials incorporated, in order to maximise the opportunity to reuse materials in the future.
- *Choose desirable materials,* which have recycling potential as well as good manufacturing and use characteristics. A key recommendation here is to use recycled or low environmental impact materials as far as possible.
- *Make it modular.* Modularity has always been a feature of automobiles. Designers can assist by standardising parts which need to be replaced and making it easy to remove those parts.
- *Eliminate unnecessary product complexity.* If too many different types of material with different properties are used in a vehicle, it becomes more difficult to characterise the material to be recycled at the end of life.
- *Make products efficient to disassemble and make the materials easy to recover.* If necessary, it should be possible to separate materials for recycling in future. For example, trace impurities and hazardous components may prevent recycling in future.

Continued ....

Box 8.7 (Continued) Design for recycling

Choosing materials wisely

In addition to this list, they have formulated some specific guidance for minimising environmental impacts from industrial products by choosing materials more effectively. Traditionally, these choices have been made with regard to cost, aesthetic appearance, structural performance, compatibility with other materials used and durability. However, since environmental criteria are also important in material choices, the following principles should be followed:

- Choose abundant, non-toxic, non-regulated materials if possible. If toxic materials are required in manufacturing, try to generate them on-site instead of having them formulated elsewhere and transported. This is because transporting toxic materials should be minimised to reduce the risk of accidental releases.
- Choose materials that either are natural or mimic natural materials as far as possible.
- Choose materials for which recycling at the end of life is feasible and for which a recycling infrastructure exists.
- Design for minimum use of materials in products, processes and product use.
- Use materials from recycling streams rather than from primary material extraction.

Source: Graedel and Allenby, (1998)

virgin materials, which may not be appropriate for the performance required in a particular application. It is expected that there will be more activities such as these in the future, resulting in more sustainable resource use in the industry.

A particular paradox in the motor industry is that while the time that a vehicle will actually last in service is increasing, the product life cycle (time for models to be replaced) is decreasing rapidly. Also, as the stringency of MOTs increased, the life of the vehicle has reduced. Insurance may also act as a force against increasing vehicle life, if the cost of repairs following an accident is greater than the vehicle's value, as the vehicle is often 'written off' even if it is possible to restore it. Increasingly, this creates a trend for vehicles to become obsolete faster but for economic reasons, rather than because of mechanical failure as tended to occur previously.

It is also a point for debate as to whether the drive for better environmental performance across the life of vehicles is something that will be driven mainly by consumers, the industry or government policy in future. Thus far, it has been the latter two groups of actors who have perhaps been the most active. However, this may be subject to change in the future, mainly because:

- Better environmental information will be available (e.g. in the form of eco-labels) to allow consumers to make better informed choices between vehicles.
- It is likely that the structure of economic taxes and benefits will be changed to internalise more of the external costs arising from vehicles (see Section 8.6).
- It may become more socially desirable to own more sustainable vehicles. For example, Toyota produces a petrol-electric hybrid, the Prius, which produces 114g/km of CO_2 and has become popular among Hollywood stars such as Cameron Diaz, Leonardo DiCaprio, Harrison Ford and Calista Flockhart. The Japanese company is now working on a 'green 4x4', expected to go on sale in 2004, which will produce less than 200g/km (Webster, 2003).

Prohibition of materials

Legislative pressures may lead to the prohibition of certain materials in the manufacture of vehicles. Asbestos has already been banned and heavy metals such as lead, mercury and cadmium in new cars have been banned from 1 July 2003[36]. Other materials that will soon be banned include certain flame-retardants, such as the brominated flame retardants (polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)).

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[36] *The ELV Directive has banned certain toxic metals in new vehicle manufacture, while the Restriction of Hazardous Substances in Electrical and Electronic Equipment (ROHS) Directive (2002/95/EC) Directive places a general ban on four heavy metals (lead, cadmium, mercury and hexavalent chromium) and the brominated flame retardants PBB and PBDE from 1st July 2006.*

Complete prohibition of materials can sometimes impede progress towards sustainable development, as problems may be caused by the way materials are used rather than because of the characteristics of material used. They are also sometimes replaced by materials which have similar harmful properties to the prohibited materials, with no net benefit. However, the materials discussed above are acknowledged as problematic and often escape from the industrial system into natural systems, where they cause a number of serious problems. Further prohibition of materials in the future will need to be appraised on a case by case basis.

However, it is likely that the motor industry will become more proactive in choosing to 'prohibit' materials without governmental intervention, as IPP for the industry is implemented. Many motor manufacturers already use life cycle approaches to appraise their environmental performance, although in many cases the original data collected and results are not in the public domain at present. It is expected that more use may be made of such techniques in future to effect better material selection in the industry. This will of course be assisted by the wider availability of life cycle information, which should arise as a consequence of the IPP implementation. For example, environmental concerns over polyvinyl chloride polymers (PVC) include dioxin emissions when incinerated and the use of phthalate plasticisers, which are thought to be endocrine disrupters. It is also difficult to recycle and is likely to be phased out by car manufacturers in the near future

It will also be interesting to see if an extension of this approach could result in certain materials being prohibited in the motor industry for reasons other than intrinsic toxicity, such as that they are not capable of being recycled. It is likely that the EU and Member States will consider all of the policy tools available to them before opting to use a single and rather severe measure such as prohibition.

8.6 Economic influences on technological choices and behaviour

Fiscal measures may be employed to effect changes towards more sustainable resource use, by changing consumer demand for particular technologies and influencing the future development of design trends and manufacturing processes in the motor industry. There are two generic policy approaches at present to applying economic pressures to change technologies or behaviour in the context of the motor industry:

- Subsidising of new resource efficient technologies which require some initial economic support to develop markets.
- Taxation of technologies which cause harmful effects such as pollution, so that the external costs associated with rectifying harmful effects is borne by those using or producing the technologies. This embodies the principles known as 'polluter pays' and 'producer responsibility' respectively .

This section reviews some current examples where these generic economic approaches have been applied to the motor industry and discusses how they may be applied in future, to increase sustainable resource use in the sector.

Influencing consumer fuel choices

An account of the success of making subsidies available to support fuel switching has been given in Section 8.2. Recent experience suggests that changes in taxation can also be utilised as a successful policy instrument to influence consumer fuel choices. Since 1990 there has been an overall trend of a reduction in the consumption of motor spirit[37] in the UK. Consumption in 2002 was 18% lower than the peak of 24 million tonnes in 1990. There are a number of reasons for this observation.

Figure 8.7 illustrates the large differential that existed between the price of 4-star leaded petrol and DERV fuel, with the latter being priced at similar levels to premium grade unleaded petrol. This encouraged motorists to convert to diesel-engined vehicles. Whilst the number of petrol-engined vehicles licensed only grew by 8% from 1992 to 2002, the number of diesel-engined vehicles licensed has increased more than four-fold in the same period. This price differential had a relatively large effect on influencing fuel choices in vehicle purchasing decisions due to other market changes:

- Diesel-engined vehicles tend to be more efficient than their petrol equivalents. It has been found that diesel-engined cars averaged 39 miles per gallon of fuel between 1999 and 2001, compared with 30 miles per gallon for petrol-engined cars (DTI, 2003b). This adds to the cost efficiency of running a diesel vehicle in comparison with a similar petrol vehicle.
- Historically, diesel vehicles used to be more expensive to purchase than equivalent petrol vehicles and their on-road performance was inferior by comparison with petrol equivalents. However, improvements in technology and a reduction in purchase prices for diesel-engined vehicles has largely eliminated the perceived advantages of petrol-engined vehicles in this respect.

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[37] *Defined as 'blended light petroleum product used as a fuel in spark-ignition internal combustion engines (other than aircraft engines)' and includes leaded and unleaded petrol fuels (DTI, 2003b).*

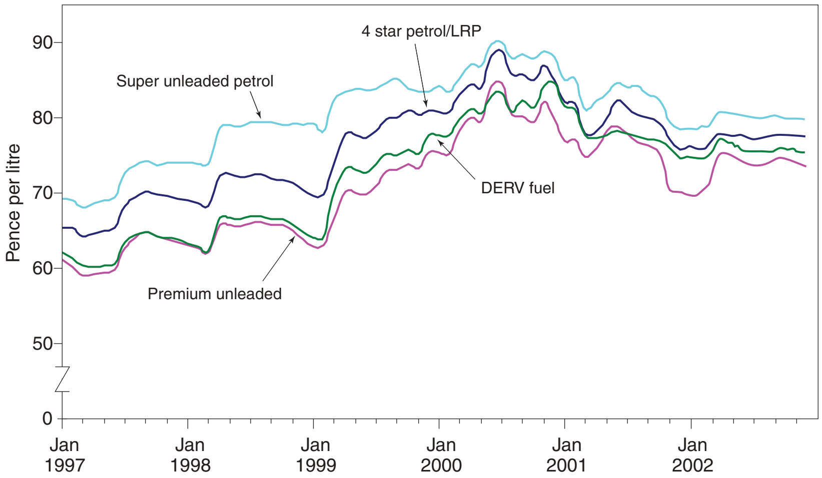

Figure 8.7 Prices of motor spirit and DERV fuel in the UK, 1997 to 2002 *(Source: DTI, 2003b)*

In the mid 1990s, changes to the taxation system were made to remove the price differential, on the grounds that DERV was more harmful to the environment. It is thought that this considerably reduced the rate of switching to diesel-engined vehicles than would have been the case without intervention (DTI, 2003b).

Fuel switching has also occurred between different types of motor spirit (leaded and unleaded). This was influenced by the:

- Large differential between the price of a litre of leaded and unleaded petrol prior to 2000 due to taxation, where unleaded petrol has always had a considerable price advantage.
- Implementation of the Auto-Oil Directive, which resulted in banning the general sale of leaded petrol (4 star) from 1st January 2000.

The forced switch to unleaded petrol provided an incentive for people to change their older vehicles to either new models or those of more recent manufacture. As a consequence, virtually all petrol sold since 2000 has been unleaded, an increase from 72% in 1997. The resulting reduction in the age of the vehicle stock has possibly further reduced overall petrol consumption, as newer vehicles tend to be more fuel efficient due to improved technology.

A differential rate of duty was introduced for Ultra Low Sulphur Diesel (ULSD) in 1997 (3p per litre in March 2000) on environmental grounds. This has had a significant effect on influencing consumers to preferentially use the fuel. This was so successful that HM Customs and Excise estimated that at the end of 2000, all the sales of DERV were in fact ULSD fuel. A similar duty (of 1p per litre as at March 2000) was also introduced to help the UK oil industry to provide the infrastructure for the provision of a Ultra Low Sulphur Petrol (ULSP). ULSP can lead to reductions in emissions of NO_x of up to 6%, CO of between 6 and 18% and reductions in HC emissions of up to 15%. There are also substantial reductions in emissions of non-regulated pollutants such as benzene, 1,3 butadiene, acetaldehyde and formaldehyde. The wider availability of ULSP will also allow the introduction of new engine technologies such as gasoline direct injection (GDI) that can improve fuel efficiency by up to 20%. (DTI, 2003b).

Economic measures to reduce CO_2 emissions by influencing vehicle design

Fiscal measures could have a large effect on the future development of design trends and manufacturing processes. For example, in 1996 the EU set a target of 120 CO_2 g/km emissions from new passenger cars to be attained by 2005 or at the latest by 2010 in its report on options for the taxation of passenger cars (EU, 2002). The EU report discussed different uses of fiscal measures to meet the target drawn from the experience of Member States. By the end of 2002, the UK was the only EU Member State to have adopted an emission-based annual taxation system for cars (Vehicle Excise Duty (VED)), following from the commitments set out in the Government's new draft strategy for road vehicles and fuels (DFT, 2002b; HM Treasury, 2001). As an incentive to introduce vehicles with lower CO_2 emissions, the VED, previously differentiated for two classes by engine size, adopted a taxation system differentiated for five classes by CO_2 emission level. A further low taxation band, especially created for cars emitting 100 g/km of CO_2 or less came into force from May 2003, widening the gap between the lower and higher bands from a difference of £75 to £100 (DFT, 2003a).

A second fiscal measure to reduce car emissions identified across the EU is a company car taxation (CCT) system which would reflect the emissions' contribution of this category of vehicles. Company cars are on average larger and more powerful (and therefore more polluting). At the same time, they are also used for higher yearly mileage[38] and therefore contribute highly to total traffic levels, including congestion, and represent around 40% of the sales of new passenger cars. As announced in the Budget in 2000 (HM Treasury, 2000), from April 2002, the CCT was reformed so that tax rates are now based on a percentage of a car's list price, graduated according to 1 of 21 CO_2 emission bands (measured in g/km). The charge builds up from 15% of the car's price to a maximum of 35 per cent, by 1% steps for every 5g/km of CO_2 above a specified minimum qualifying level. The level of CO_2 emissions qualifying for the minimum charge were set to reduce each year as follows:

- 165 g/km in 2002/03.
- 155 g/km in 2003/04.
- 145 g/km in 2004/05.

The Budget in 2003 announced that the level of CO_2 emissions qualifying for the minimum charge in 2005-06 would be reduced by 5g/km CO_2, at 140g/km CO_2. Diesel cars (except those meeting the Euro-IV emissions standard) are subject to a supplement of 3% of the car's price, up to a maximum of 35%, due to their higher emissions of particulates and other local air pollutants. It has been estimated that these changes will save around 0.5 to 1.0 Mt of carbon emissions per year by 2011-12 (HM Treasury, 2003).

Emissions reductions from the combination of measures adopted to reduce vehicle emissions in the UK is estimated at 4 Mt of carbon emissions per year (UNFCCC, 2003). However, the Government has acknowledged that further improvements are needed for the VED rates to act as an incentive for the public to develop a preference for smaller cars, which tend to have lower rates of emissions. Similarly, the CCT system will be further developed to support the 2012 target for introduction and take up of very low carbon cars. If fiscal measures remain the same as 2003 levels, the Institute for Public Policy Research has calculated a growth in CO_2 emissions by 15% in 2020 from road transport (IPPR, 2003).

The motor industry has reacted to these fiscal changes by innovating to produce a number of vehicles with lower carbon emissions. The SMMT started to monitor the reduction of average new car's emissions in 1997, which demonstrated the industry's commitment towards meeting the agreed target of 140 g/km of CO_2[39]. The average new car in 2002 emitted 174.2g of CO_2 per km, 8.2% less than the 1997 baseline and 1.9% below the 2001 average (SMMT, 2003a). The top ten 'greener' cars on sale in the UK in 2002 are shown in Table 8.4.

Table 8.4 UK top ten 'greener' cars in 2002

Model	*Fuel type*	*CO_2 g/km*
Honda Insight	Petrol/Electric	80
Citroen C3	Diesel	110
Renault Clio	Diesel	110
Peugeot 206	Diesel	113
Smart	Petrol	113
Toyota Yaris	Diesel	113
Ford Fiesta	Diesel	114
Toyota Prius	Petrol/Electric	114
Audi A2	Diesel	116
Ford Fusion	Diesel	116

Source: SMMT, 2003a.

Currently, about 13.6% of the new vehicles sold emit less than 140 g/km (from a 3.9% share in 1997). The latest registrations data available shows how the small cars' classes (Class A 'Supermini' and Class B 'Mini' such as Mini, Smart, Clio, Peugeot 206 etc.) dominate the market taking 33.8 per cent of August 2003 registrations, reflecting the market share of about 33.5% registered for 2002 (SMMT, 2002). It is not clear to what extent the taxation system influences more sustainable choices of vehicles by consumers, as a rise in VED is not likely to influence the choice of more affluent consumers, unless very high and unpopular tariffs are applied to the luxury car market (which tends to consist of larger and more polluting vehicles). This is because at the moment, the price differential between the top and bottom of the VED scale is negligible to those on high incomes.

Alternative taxation systems to reduce car use rather than focussing on car ownership

The VED, being a flat ownership tax, does not address vehicle use at present. It has been suggested that the principle of 'the polluter pays' would probably be better reflected by fiscal measures charging vehicles users at peak hours in urban areas, where the congestion and associated costs to society (including noise, accidents and pollution, the latter higher from slow driving cars) are high. Mumford (2000) has estimated that 72% of the total cost to society for road use is actually borne by motorists at present. Mumford has also identified how the system gives rises to inadequacies. He has calculated

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[38] *Company cars in the UK account for almost 20 per cent of total car mileage (HM Treasury, 2000).*

[39] *The European Council and the European Parliament set a target of 120 CO_2 g/km emissions from new passenger cars to be attained by 2005 or at the latest by 2010 in 1996. Three main levers were identified for the purpose, i.e., technical improvements in terms of fuel economy and consequent fuel-economy labelling, and fiscal measures. The car industry committed itself to reach a target of 140 g/km CO_2 emissions through technological development and consequent market change.*

that the social cost of an HGV driving through a urban centre at peak hours is 100 times greater than the social cost of a private car travelling through the countryside, even though the actual fiscal burdens on the two users do not reflect it. Mumford therefore suggests that a national road usage toll or congestion charging scheme would be the best way to address the inequality.

The IPPR (2003) commissioned Imperial College to undertake some research on the effects that a national congestion charging scheme could have if it were to be introduced on roads throughout England in 2010. Given that fuel costs are expected to continue to fall, the results suggest the development of a congestion charging on a revenue raising basis is required, where charges are added to fuel duty costs. If the scheme was introduced in 2010 as described, the scenario's development has investigated the likely effects, which include:

- Reducing road traffic in England by nearly 7%.
- Reducing CO_2 emissions by just over 8%.
- Increasing the use of buses by just over 11%.

Under this taxation system, the average money cost per km could be just over 10p for a rural motorist (just 1p more than in a BAU scenario) and about 20p for an urban motorist. Therefore it would not dramatically increase the average costs of motoring in rural areas where there are often few public transport alternatives to the car.

8.7 Influencing choices of transport mode

Reducing car dependence

Based on the data collected for 2000, it is clear that use of the car is the part of the motor industry responsible for the majority of energy use and air emissions quantified (see Chapters 5 and 6). Increases in traffic are expected to continue, unless significant measures to reduce this traffic growth are undertaken. Road traffic in the UK is expected to increase by between 24% and 51% from 1996 to 2016 (DfT, 1997b) (see Figure 8.8). Journey times are expected to increase significantly, in some areas very substantially, with times spent on journeys on urban motorways predicted to double in the peak period by 2031 (DfT, 1997b). In outer London, one-fifth of the time taken in making a journey is spent stationary. It is predicted that on the busiest roads in many cities, journey times in the rush hour could lengthen by as much as 70% over the next twenty years. This also exacerbates the environmental impact of vehicle use: even cautious estimates suggest traffic related emissions of CO_2 are 25% higher in the centres of large cities, as a result of congestion (DfT, 1997b).

The Government appreciates the need for moving goods and people as 'essential for economic success' (DTI, 2003a). However, it is not clear that moving goods and people, and hence economic success, need necessarily to be linked with high levels of road transport use (see Box 8.8). The government is committed to reduce the environmental impacts associated with road transport by promoting development of cleaner vehicles and by attempting to reduce the negative effects of traffic growth.

Scenario 6: Effect of increased use of public transport on CO_2 emissions

Whilst the drive for cleaner energy sources and more energy efficiency in vehicles is welcome (as discussed in Section 8.2), another policy option available is to promote the use of alternative transport modes instead of the passenger car. Similar issues have been explored in Chapter 6 in the context of policies to reduce emissions.

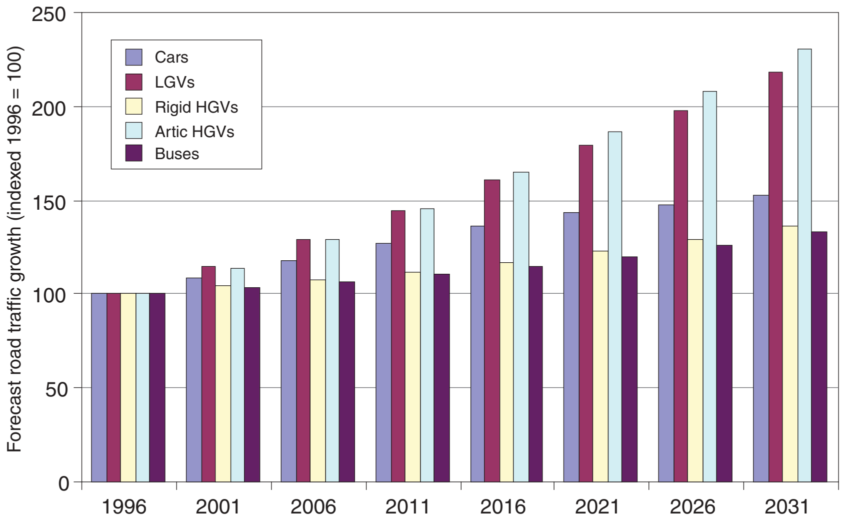

Figure 8.8 Forecast road traffic growth 1996-2031 *(Source: DfT, 1997b)*

Box 8.8 Decoupling car use, economic growth and population density

Comparative research of transport in different European cities has reached two important conclusions. Firstly, *car usage is not a function of a city's wealth*. For example, in 1990, Athens and Dublin were poorer than Bologna and Helsinki, but their inhabitants were more reliant on the private car to get to work. Secondly, *car usage is also not a function of population density*. For example, Dublin and Helsinki have similar population densities, but in Dublin car usage is higher than in Helsinki. These are the two mostly frequently cited variables for explaining the apparently unstoppable expansion of car usage. These results lead directly to a further conclusion of paramount importance: *urban car systems are socially shaped*. As such, they are influenced by planning policies and local socio-political conditions.

In research by Wickham (1999; 2002), Bologna and Helsinki appear as best practice cities in terms of reducing car use, which contrast with Dublin and Athens as worst case cities. The research found that differences should be understood in terms of 'technological trajectories'. That is, at certain key developmental points, the city starts to follow a pattern of development which then becomes 'normal' and difficult to change. It is also possible to identify 'switching points'. These are the points at which the entire trajectory of development is queried and altered. An example of a switching point given in the study relates to Helsinki, where the Smith-Polvinen plan of the 1960s created a vision for the future of the city dominated by urban motorways. The resulting public outcry forced a re-orientation of policy towards revitalising public transport, to create an alternative to this unpopular plan.

Thus moving Dublin and Athens towards more environmentally sustainable forms of mobility is difficult, because the existing system relying on private car use has become an integral part of patterns of transport and spatial planning. The car has become embedded in the urban development and the social interaction of each city. It is therefore plausible that the differences between the best and worst practice cities described in the research will continue into the future without any action to intervene.

However, the results of the study are a reminder that there is nothing inevitable about the growth of car use alongside economic growth or population density. The findings demonstrate that urban planning plays a significant role in the development of city transport infrastructure. This provides some hope that car use and economic growth may be decoupled, providing more sustainable transport solutions.

Sources: Wickham, J, 1999 and 2002.

Method and assumptions

The scenario has calculated the consequences of a 25% increase in passenger km in public transport (buses and rail) by 2020, with consequent reduction in car passenger km travelled. The effect of this modal switch is also matched with the earlier scenario relating to low carbon emissions from PSVs. The assumptions required for the assessment were that:

- The emissions per passenger km were calculated assuming a single passenger for each car and 20 for each bus. A value of 116 g of CO_2 per passenger-km was used for the rail; 174 for car and 90 for buses and coaches[40].
- The increase in public transport travelling is split equally between rail and PSVs.

Results

Assuming that all the vehicles in the PSV fleet are low-carbon fuelled, the calculations give a total of 70.6 Mt of CO_2 emissions versus the 120.7 Mt for a BAU situation. This equates to a potential reduction of 42% in CO_2 emissions.

In the UK currently 80% of all personal travel is conducted by car (see Box 5.3, Chapter 5). If it is accepted that increasing mobility of people and goods is necessary for continuing economic growth in the UK, then more attention will need to be paid to promoting alternatives to car use in future. Box 8.8 explores some common assumptions about the links between car use, economic growth and population density and asserts that urban planning may have a pivotal role to play in minimising car dependence.

Outside of the vehicle industry itself, land use planning can influence changes by placing restrictions on the size and number of car parking spaces available to drivers.

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[40] *Based on carbon emission data for rail travel, cars, buses and coaches sourced from NAEI (2003).*

Car free housing is being introduced in cities as diverse as Amsterdam, Berlin, Bremen, Cambridge and Edinburgh. In London, a number of local borough councils are encouraging the development of car free housing and Camden's approach to planning policies is described in Box 8.9. It seems likely that measures to influence a reduction in the use of private cars and to promote the use of alternative transport modes will continue to be pursued in future.

8.8 Summary

Clearly, there are a number of different drivers supporting useful action towards the objective of achieving more sustainable resource use in the motor industry.

Some generic reasons why certain policy actions have been successful can be discerned, which indicates ways that these useful trends may be encouraged to continue into the future and where they might be expanded upon. These reasons include that:

- A variety of interested parties continue to be involved in defining the actions required. This ensures that actions are practical and are capable of being implemented by those affected. For example, it is unlikely that reductions in congestion can be effected without attention to a whole plethora of issues including changes in the planning system, technological changes in car design, application of fiscal measures, making alternatives to the car more available and changing patterns of commuting. This will require input from a variety of industrial partners, government, NGOs and the public, if the changes are to be effective, lasting and politically acceptable.

- There has been a commitment to analyse problems identified across the three spheres of experience considered in defining progress towards sustainability (economic, environmental and social) to ensure that problems are not simply displaced from one sphere to another. For example, in reducing congestion, it is not acceptable to simply change the costs of motoring such that those on low incomes in rural areas no longer have access to any form of mobility, which would be regarded as socially regressive.

Box 8.9 Policies for car free housing in Camden

Camden Borough Council has been encouraging the development of car free housing schemes since 1997. In such schemes, there is no on-site car parking except for disabled drivers. Development of car free housing is supported by planning policy in locations that are:

- Easily accessible by public transport.

- Near a range of amenities, including shops and leisure activities.

- Within a controlled parking zone.

This approach is supported in the following planning policy documents:

- Government planning policy guidance (including: PPG 3 on housing and PPG 13 on transport).

- 'Our towns and cities: the future - delivering an urban renaissance', the urban white paper (DETR, 2000c).

- The Mayor of London's 'Transport Strategy' and 'London Plan'.

The space traditionally reserved for car parking is instead used for more housing units or leisure uses such as more play spaces and cycle parking. Unsurprisingly, residents of car free housing schemes are not eligible for on-street parking permits. By eliminating off-street parking provision for residents of car free housing, a greater proportion of the development site may be used for flats or houses themselves. Alternatively, it can allow for attractive landscaping or higher density housing within the development in place of on-site car parking, in addition to promoting car free greener and healthier lifestyles.

Up to April 2003, planning permission for 2,000 car free housing units (in 175 residential schemes) had been granted by the council, which it is anticipated will save approximately 4,000 car trips each day when they are all built.

Source: Camden Borough Council, 2003.

However, it is also apparent that most policy activity in the motor industry has focussed on manufacturing rather than controlling vehicle use thus far. Given that this study has found that car use is the single most significant source of energy use and emissions in the motor industry, it is unlikely that this emphasis in policy can continue, if continuing progress is to be made towards more sustainable resource use. It is expected that new policy initiatives will have the objective of reducing journeys made by car in future, which will also reduce associated problems such as:

- Congestion.
- Accidents.
- Air pollution.
- Noise pollution.
- Energy use.

Given that many people in the UK are reliant on cars and road transport generally for mobility, changes made to reduce journeys will require careful consideration to ensure that they:

- Are practical.
- Are equitable.
- Provide alternatives where possible.
- Ensure that any monitoring methods considered do not cause undue concern with loss of privacy or infringe on other civil liberties.
- Are cost-effective.

9 Conclusions and recommendations

9.1 Conclusions

The motor industry is under increasing pressure to demonstrate that its activities are becoming more sustainable over time. Increased regulation and competitive pressures have been the two main drivers but actions to achieve this objective have tended to be focussed at the individual company level historically, leading to a fragmented approach within the industry generally. However, a number of new legislative requirements driven by the concept of 'producer responsibility' will require an industry level approach and a greater degree of collaborative activity than has been the case to date. For example, the ELV Directive has implementation and reporting requirements spanning the whole of the motor industry. Such requirements imply that activities in the motor industry will require monitoring at a more strategic level than in the past. The mass balance data in this report are useful in providing such high level information on resource use, so that suggestions can be made for improvements in industry practices in the future.

Data availability and quality

A significant problem in this project has been the lack of mass data available to undertake the analysis. The main reasons for this were as follows:

- Data were not always available from motor and part manufacturers, usually for reasons of confidentiality.

- Data were not always available from the processors/reprocessors of vehicles reaching the end of life, usually because the information was not normally collected and reported on.

- Some use data were available, but gaps remained which were addressed by performing calculations using information available.

- Data on energy use and emissions are largely only available at the level of the whole industry, and assumptions were necessary to analyse the data further and to account for the proportion of other industries supplying parts to the motor industry.

The data collected have been presented and discussed in terms of data availability and quality throughout the document, with the detail discussed in Appendices 2, 3 and 4. Some particular problems were encountered in using PRODCOM data, because:

- Data are suppressed for categories where confidentiality may be an issue (e.g. if there are too few companies involved).

- Data are not always communicated in mass, but may also be reported as units or economic value of sales. In these cases, a means is required to convert the data into mass for inclusion. There is no agreed means to carry out this conversion at present.

- It is difficult to account for the stock of parts at the moment, which may cause inaccuracies in reporting resource efficiency in the industry.

These problems have been overcome by the use of conversion factors and assumptions. However, this has raised more difficulties, which can be summarised as follows:

- The validity of the assumptions made is not capable of empirical testing at present, in the absence of more complete data.

- This can also lead to some difficulty in identifying areas where double counting of mass may be occurring.

These difficulties would suggest that there is an urgent need for better monitoring and reporting of resource use in the motor industry. In particular, the data collected should be transparent and representative of practice in the UK. In combination with social and economic data collected in other studies, this would allow meaningful reporting on the extent to which the industry's practices can be considered sustainable.

Despite these difficulties, it has been possible to derive an overview of the resource use of the motor industry. This has proved useful in mapping areas where practice could be improved in future. It also provides a baseline, should periodic tracking of resource use be required in future. For instance, this approach would be useful in monitoring the effectiveness of policies designed to encourage better use of resources.

Resource use, wastes and emissions in the industry

Resource use

In order to produce 4.36 Mt of vehicles and components, 4.00 Mt of primary products were required, plus 3.08 Mt of imported components and 0.15 Mt of ELV components sold for reuse. This gives a total material resource requirement of 7.23 Mt.

Alternatively, the total material resource requirement may be calculated from the sum of the masses of products created (4.36 Mt) and wastes produced (3.58 Mt) by the production stage of the motor industry in 2000. Calculated in this way, the total material resource requirement is 7.94 Mt[41].

In addition, 0.72 Mt of fluids were required for vehicle use activities in 2000.

The UK motor industry used 41.37 Mt oil equivalent of energy. 0.69 Mt of vehicles were added to its stock of vehicles[42].

Wastes

The UK motor industry produced 7.09 Mt waste. To put this in perspective, this equates to 0.12 tonnes of waste per capita for the year 2000. This compares with 0.5 tonnes of household waste produced per capita in the same year[43]. This can be thought of as a further 20% increase in the waste produced by each person in the UK.

Production of waste in the sector will require increasing attention to targeting efforts to reducing the environmental impacts over the whole product life cycle. As described in Chapter 8, although there is sufficient processing and reprocessing capacity to meet a recovery figure of 75-80% for current arisings of ELVs, this will need to be expanded considerably to meet the more stringent recovery targets in the ELV Directive. This is because the mass of ELV arisings is expected to rise, but also because the non-metallic waste streams (such as plastics, textiles and glass) are currently not routinely recovered in the UK, due to a lack of incentive (economic or otherwise). Improving the lifespan of routinely replaced parts would also have a significant effect on waste arisings from maintenance (e.g. tyres, brake pads, etc.) by avoiding waste production.

This in turn highlights the importance of choosing materials wisely and designing modular parts during production of new vehicles and components, in order to maximise the possibility for reuse, recycling or recovery at the end of the product's life. However, attention should be paid to allow this to be achieved without shifting environmental impacts to other life cycle stages. This type of design philosophy accords with current attempts to encourage integrated product policies for different industry sectors in EU member states.

Resource efficiency

The resource efficiency of the industry may be examined further by calculating the ratio of products manufactured by the motor industry to its total material requirement, expressed as a percentage as follows:

$$\frac{\text{Mass of products manufactured by the motor industry}}{\text{Total material requirement of the motor industry}}\%$$

If this calculation is performed using the data presented in Figure 2.1 (Chapter 2), then the resource efficiency of the motor industry is estimated lie in the range 55 to 60%[44]. (see Section 2.2).

Energy and emissions

The use of vehicles accounts for 96.5% of the energy used and 97.9% of the emissions to air quantified for the motor industry in 2000. This equates to a fuel requirement of 39.91 Mtoe (petrol and diesel) and 119.69 Mt of emissions to air[45] for vehicle use alone. To put this into perspective, vehicle use accounted for 23.3% of energy used and 21.4% of emissions to air from the whole of the UK in 2000. Vehicle use is also a major contributor towards the UK's emissions of greenhouse gases and potential contribution towards global warming, accounting for 17% of the UK total for 2000 (expressed as GWP).

Switching fuels to low carbon alternatives can reduce both energy use and emissions. Other methods of reducing emissions that have been highlighted by this report include:

- Reducing reliance on road transport in the UK.
- Driving in accordance with best practice guidance to get maximum efficiency from vehicles in use.
- Changing the design of vehicles to make them more aerodynamic and using lighter vehicles to reduce the energy required to propel vehicles.

Summary

The report has illustrated the current magnitude of resource use, waste production and emission generation from the motor industry in the UK. Demonstrating that the industry is continuing to make progress towards more

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[41] There are two possible reasons for this discrepancy. Firstly, the data available to quantify the primary products and components consumed in 2000 is suspected to be an underestimate, due to suppressed and unavailable data (see Figure 2.1 and Box 2.1 for details). Secondly, the figures obtained for waste generated may overstate the mass arising directly from motor industry activities. Detailed explanation of the data sources and calculations is presented in Appendices 1-4.

[42] In this study, addition to stock for products is the sum of the mass of production and imports minus the exports.

[43] Estimated at 507 kg of household waste arising per person per year for 1999/2000 (DEFRA, 2003b).

[44] Two figures for total material resource requirement were obtained by using different data sources. The reasons for this are explained further in Section 2.1 and 2.2.

[45] Excluding water vapour from combustion during vehicle use (47.00 Mt)

sustainable resource use will require further reductions across all three parameters. This will require a coherent approach to product development, which may benefit from a life cycle perspective of industrial practices and consumer requirements.

There is at present no single organisation with the responsibility for devising policy, monitoring practices, conducting research and providing best practice guidance on sustainability issues for the motor industry. While acknowledging that progress has been achieved by voluntary actions within the motor industry (see Box 9.1), there is a need for better strategic direction to address certain sustainability issues. A number of sustainability issues have been identified in this report which cannot be addressed by industry actors alone. An

Box 9.1 'Towards Sustainability': the automotive sector sustainability strategy

'Towards Sustainability' was launched by SMMT with 11 founding signatories in March 2000 to provide a sustainability strategy for the automotive sector. Today the strategy is supported by 24 signatories. The strategy is reviewed annually and seeks to provide 'a framework to:

- Develop a vision of sustainable mobility.
- Address the sector's environment, economic and societal pressures.
- Assess the sector's performance across the triple bottom line.'

The strategy is comprised of:

- An annual report, providing a description of the performance of the industry. This includes reporting against a set of key performance indicators.
- Multi-stakeholder dialogue, which is used to prioritise sustainability themes during the year. For example, promoting responsible product use was a theme in 2002.
- Specific actions linked to themes to achieve improvements. For example, the production of a best practice guide for drivers in 2002 (entitled 'Driving the Future – Your Guide to More Responsible Driving').

Progress has been made against a number of indicators that it is within the resources of the automotive industry to address directly. For example, the CO_2 emissions for new cars fell to 174.2 g/km in 2002, an 8.8% reduction on 1995 levels. However, on sustainability issues which are outside the direct control of the industry, it is often difficult to make progress without concerted action from other stakeholders. Establishing commitment to such actions in the absence of a single organisation having a strategic, co-ordinating role and the capacity to implement policy changes to support them can be very challenging.

A good example of a sustainability issue requiring such action is the improvement of air quality. While the automotive industry may influence the technical aspects relating to reducing emissions from new vehicles (e.g. by producing vehicles to run more efficiently on cleaner fuels), some air quality issues relate to how vehicles are currently used (e.g. congestion and reducing CO_2 emissions from all road transport). It would be unreasonable to expect the automotive industry to address such issues independently of actions in other sectors, since many of the means to address them are unavailable to the industry. It is for this reason that this report advocates the view that such sustainability issues could be addressed more effectively by a single strategic body supported by a wide number of interested parties drawn from industry, government and non-governmental organisations.

Similar views are espoused by SMMT in the 'Towards Sustainability' report, stating that the challenges presented by sustainable mobility for the automotive and other parts of society demonstrate 'the need for developing a more integrated approach and the need for co-operation between all sectors of society, including industry, business, government and consumers (i.e. drivers)'. SMMT also advocates that the approach would need to combine 'economic instruments, new technologies, infrastructure investments and other policy actions, at both UK and EU levels'.

Source: SMMT, 2003b.

example of such an issue would be reducing air emissions from existing road transport vehicles. These issues share the common feature of having responsibilities and accountabilities shared between a number of stakeholder groups. It is argued that addressing such issues will require support from additional stakeholder groups in order to achieve further progress (drawn from industry, government and non-governmental organisations) and that this is best addressed by establishing a single, strategic organisation to co-ordinate action.

Recent advances in 'integrated product policy' and 'producer responsibility' legislation are expected to accelerate progress towards establishing an organisation with the ability to provide such strategic direction in future, which will necessarily include a wide diversity of stakeholders.

9.2 Recommendations

The conclusions suggest that implementation of the following five broad recommendations is required to stimulate more sustainable practices in the motor industry (Table 9.1). Each recommendation has a list of actions associated with it and suggestions for stakeholders who will need to lead on them (Table 9.2 to Table 9.6). It should be noted that not all of the actions may be practical to implement at present, but are indicative of requirements to ensure that the motor industry can demonstrate that its practices are sustainable in the future. It is also acknowledged that progress towards some of the actions is already being made. The actions are not listed in order of priority.

Table 9.1 Recommendations to accelerate progress towards more sustainable resource use in the motor industry

1 Better monitoring and reporting of resource flows.

2 Creating new relationships between motor industry stakeholders to create progress towards achieving better resource productivity.

3 Invest in research to define 'Design for Environment' principles for the motor industry, with the objective of increasing resource productivity and reducing reliance on scarce or hazardous materials.

4 Implementing practical measures aimed at stimulating action across the whole industry to minimise resource use, avoid waste production and maximise resource recovery.

5 Implementing practical measures to ensure that environmental impacts associated with vehicle use are minimised.

Table 9.2 Monitoring and reporting procedures

Better monitoring and reporting of resource flows

	Action required	*Parties involved*
1	Establish national industry wide system for data collection, analysis, monitoring and reporting on material use.	Government, Industry
2	Investigate the feasibility of making privately held information on the life cycle impacts of vehicle production, use and disposal more freely available.	Industry, Trade associations, Government
3	Establish industry accepted conversion factors for ONS recorded non-mass data to mass data.	Trade associations
4	Develop relevant means of communicating the environmental performance of the industry with respect to the sustainability of its practices. The means could include established methods (e.g. Environmental Product Declarations, Sustainability Indicators, etc.), but entirely new approaches may be desirable.	Government, Industry
5	Require the inclusion of resource use and emissions in company environmental reporting.	Government, Industry
6	Require water companies and the Environment Agency to record water use by SIC.	Government
7	Require sewerage undertakers to record discharges of aqueous wastes to sewer by SIC.	Government

Table 9.3 Stimulating stakeholder action on resource productivity

Creating new relationships between motor industry stakeholders to create progress towards achieving better resource productivity

Action required	*Parties involved*
1 Set up a motor industry wide initiative to review future social and economic trends with a view to predicting possible future resource and waste management needs. (This could be a broader forum covering all industries).	All stakeholders
2 Set up a motor industry wide initiative to drive forward policies and actions aimed at reducing resource use and maximising resource recovery.	All stakeholders
3 Set up and fund a dedicated programme of research aimed specifically at improving resource productivity in the motor industry.	Government, Industry
4 Devise action plans to target specific material streams in the motor industry where resource use is high and current recovery schemes are lacking (e.g. plastics).	Government
5 Setting material recovery targets as part of such action plans.	Government

Table 9.4 Design for environment

Invest in research to define 'Design for Environment' principles for the motor industry, with the objective of increasing resource productivity and reducing reliance on scarce or hazardous materials

Action required	*Parties involved*
1 Funding research to appraise the life cycle benefits associated with different management options for wastes arising from ELVs (e.g. different options for market expansion for recyclate arising from the motor industry), to support environmentally sound policy development.	Government, Industry
2 Reduce the number of disparate materials used in motor vehicle manufacture to make recovery more feasible.	Industry
3 Focus attention on designing out hazardous materials and using less hazardous substitutes where possible	Industry
4 Create new information networks to share best practice while maintaining confidentiality where appropriate.	All stakeholders
5 Investigating the use of more lightweight materials in vehicle manufacturing.	Government, Industry
6 Funding research into the adaptation of vehicles to make use of new cleaner and more efficient fuel sources.	Government, Industry
7 Designing vehicles and their constituent parts to last and be modular, thus reducing vehicle maintenance inefficiency and promoting the ability of parts to be reused in future.	Industry
8 Investing in research to influence more sustainable vehicle purchasing and driving behaviour.	All stakeholders

Table 9.5 Practical measures to increase resource productivity

Implementing practical measures aimed at stimulating action across the whole industry to minimise resource use, avoid waste production and maximising resource recovery

	Action required	*Parties involved*
1	Implement measures to eliminate the landfill or incineration of potentially recoverable material resources.	Government
2	Collect and disseminate data on the availability of processing facilities and materials recognising the need for data to be current and available at a local level.	Local authorities, Industry
3	Undertake a review of reprocessing capacity and identify materials with greatest potential for improving resource recovery.	Government
4	Develop and implement a national strategy for increasing reprocessing capacity for the materials in 3 above.	Government
5	Investigate methods of stimulating the market for recyclates, particularly from the material streams identified in 3.	Government
6	Extend the UK administrative arrangements governing the processing and reprocessing of end of life vehicles to cover all vehicle stock, not just those named in the Directive, to ensure that 95% of all end of life vehicle stock is recovered by 2015.	Government

Table 9.6 Controlling environmental impacts associated with vehicle use

Implementing practical measures to ensure that environmental impacts associated with vehicle use are minimised

	Action required	*Parties involved*
1	Make knowledge of resource-efficient driving techniques part of the requirements of the driving test in the UK.	Government
2	Evaluate alternative strategies to achieve a reduction in non-essential road vehicle movements, in order to put forward a strategy to be adopted across the UK (e.g. road pricing, differential road pricing for unladen trucks, etc.).	Government
3	Fund research to investigate the appropriate use of alternative transport modes, to assist with allowing mobility in the UK to become more sustainable.	All stakeholders
4	Instigate a phased education programme to encourage efficient driving and vehicle maintenance habits in focussed groups of vehicle users across the UK.	Government, Industry
5	Working with partner organisations to implement measures across all industry sectors to reduce the level of commuting of workers within the UK (e.g. car sharing, teleworking, using public transport, cycling, etc.)	Government with input from all stakeholders
6	Updating planning policy guidance to reflect the need to ensure that developments which entail the movement of large volumes of freight or people are only permitted in areas well served by lower impact alternatives to road transport e.g. rail heads, canals, etc.	Government
7	Investigating the use of different measures to reduce car use, including congestion charging, boosting the availability of public transport and using the planning system to reduce car dependency.	Government
8	Revising incentives to encourage the relocation of logistical centres to areas well served by lower impact alternatives to road transport like rail heads, canals, etc. (e.g. freight facilities grants).	Government

Glossary

Acidification: Acidification impacts are caused by the release of hydrogen ions (H+). This is a natural process which is amplified by pollutants from human activities. Acidifying pollutants have a wide range of effects on the environment, including damage to soil, water, ecosystems and the built environment.

Acidification Potential (AP): The acidification potential of a substance i is defined as the potential number of H+ ions produced per kg of substance i relative to sulphur dioxide gas (SO_2).

Acid Gases: Acid gases are those air emissions with the potential to cause acidification.

Body in White: The exterior body panels of a vehicle which have been moulded together, for example the roof panel and the frame. This is the interface to all other technical, safety and stylistic elements of the vehicle as a total system.

Buses or Public Service Vehicles (PSV): Includes all buses and coaches, including works buses but excluding small minibuses.

Carbon Dioxide (CO_2) equivalent: A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). CO_2 equivalents are commonly expressed as 'million metric tonnes of CO_2 equivalents' (MMTCDE). The CO_2 equivalent for a gas is derived by multiplying the tonnes of the gas by the associated GWP. MMTCDE = (million metric tonnes of a gas) * (GWP of the gas). For example, the GWP for methane is 21 and for nitrous oxide 310. This means that emissions of 1 million metric tonnes of methane and nitrous oxide respectively is equivalent to emissions of 21 and 310 million metric tonnes of carbon dioxide.

Carbon Neutral: A description given to products or activities to indicate that they result in no net increase in carbon emissions to the atmosphere. It is argued by advocates that CO_2 is a global pollutant not a local one, so that reductions achieved in one place can compensate for emissions released in another. Activities releasing CO_2 can thus be offset by also carrying out activities to absorb carbon emissions at the same time. Activities to offset emissions are usually pursued when it is not practical or is considered uneconomic to reduce carbon emissions at source. Activities to offset emissions come in three principal forms (Shell UK Limited, 2003):

- Energy efficiency measures.
- Renewable energy projects.
- Forest restoration projects to sequester CO_2 from the atmosphere and turn it into wood.

However, this principle is contested in practice, particularly with respect to the latter form of carbon sequestration. Currently there are concerns that measurement techniques available are not sufficiently accurate to permit the reliable monitoring of any land carbon sinks and therefore this should not form part of the Kyoto Protocol international agreement (Fawcett *et al.*, 2002). As a result of this the UK currently excludes sequestration projects from the UK Emissions Trading Scheme. The Royal Society (2001) and Fawcett *et al.* (2002) have also highlighted a number of sources of uncertainty in the scientific understanding of the causes, magnitude and permanence of land carbon sinks.

Design for Recycling: Indicates a design strategy aimed at favouring the recycling of materials and the recovery of components for reutilization. The strategy of design for recycling and the criteria for the choices of materials and finishes are evaluated on the basis of the factors that combine to determine the environmental quality of the product and the economic incentives for recycling.

DEFRA: Department for Environment, Food and Rural Affairs.

DfT: Department for Transport.

DTI: Department for Trade and Industry.

End of Life Vehicles (ELVs): This refers to vehicles which have reached the end of their useful life and are regarded as waste.

Statutory ELVs are defined in accordance with the definition of 'vehicle'' given in the ELV Directive (Directive 2000/53/EC). This states that 'vehicle means any vehicle designated as category M1 or N1 as defined in Annex II (A) to Directive 70/156/EEC, and three wheel motor vehicles as defined in Directive 92/61/EEC, but excluding motor tricycles'. Categories M1 and N1 are described below:

- Vehicles of category M1 (vehicles having at least 4 wheels, or having three wheels when the maximum weight exceeds 1 metric tonne, used for the carriage of passengers, and comprising no more than 8 seats in addition to the drivers).
- Vehicles of category N1 (vehicles having at least 4 wheels, or having three wheels when the maximum weight exceeds 1 metric tonne, used for the carriage of goods, having a maximum weight not exceeding 3.5 metric tonnes). (Directive 70/156/EEC).

The ELV Directive uses the general definition of waste from the EU Waste Framework Directive to describe when a vehicle is considered to become an ELV. This states that a vehicle becomes an ELV when 'the vehicle is a waste as defined by Article 1a of Directive 75/442/EEC'. This in turn states that a waste is 'any substance or object (in the categories set out in Annex 1) which the holder discards or intends or is required to discard' (Directive 75/442/EEC amended by Directive 91/156/EEC).

However, not all the motor vehicle classes included in this study fall within the definition of vehicles in the ELV Directive. This study has taken account of '*non-statutory ELVs*', since they are included as part of the definition of the UK motor industry. That is, the study includes the ELVs arising for vehicle classes excluded from the ELV Directive. These include:

- Heavy goods vehicles.
- Buses and coaches.
- Motorcycles.

In this report, non-statutory ELVs are considered to be defined in the same way as statutory ELVs, with reference to the Waste Framework Directive.

Ferrous Metals: This refers to metal alloys that contain iron, such as steel.

Global Warming Potential: Global Warming Potentials (GWPs) describe the radiative forcing of 1 kg of gaseous emissions relative to that of 1 kg of CO_2. In effect, this provides a measure of the amplification of the natural phenomenon of global warming by the increase in emissions of greenhouse gases from anthropological sources. In other words, it describes the contribution towards global warming from the system studied (in this case, the UK motor industry).

Greenhouse Gases: Gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect. The two major greenhouse gases are water vapour and CO_2. Other greenhouse gases include methane, ozone, chlorofluorocarbons, and nitrous oxide.

Heavy Goods Vehicles (HGV): Goods vehicles over 1.5 tonnes unladen weight with four wheels on the rear axle and all other miscellaneous vehicles.

Kt: Kilotonnes.

Light Goods Vehicles (LGV): Light Goods Vehicles are goods vehicles up to 1.5 tonnes unladen weight with only two wheels on the rear axle.

Mass Balance: The mass balance concept is based on the principles that mass of inputs to a process, industry or region balance the mass of outputs as products, emissions and wastes, plus any change in stocks. The concept of balancing resource use with outputs provides a robust methodology for analysing resource flows.

MCIA: Motorcycle Industry Association.

Motor cycles: Motor cycles, mopeds, scooters and motor cycle combinations.

Mt: Million tonnes.

Mtoe: Million Tonnes of Oil Equivalents.

NETCEN: UK National Air Quality Information Archive.

Non-ferrous Metals: This refers to metals that do not contain iron. These are metals such as aluminium, copper, zinc, lead, and nickel.

ONS: Office of National Statistics.

Parc: Commonly used to refer to all vehicles licensed with the DVLA.

Passenger Cars: Includes cars, taxis, estate cars, light goods vans with side windows to the rear of the driver's seat (e.g. small minibuses), three wheeled cars and motor invalid carriages.

Photochemical Oxidant Creation: Photochemical air pollution is formed as a result of complex interactions between UV light and emissions of nitrogen oxides and reactive hydrocarbons to produce secondary pollutants. The secondary pollutants include a number of oxidising chemicals formed in the lower atmosphere (or troposphere), of which the best known is ozone. The mixture of primary and secondary pollutants are known collectively as smog, which has a number of adverse effects. In impact assessment methods, the photochemical oxidant creation potential for a pollutant is used to describe the formation of ozone in the troposphere caused by the emission of that pollutant.

Products of the European Community Inquiry (PRODCOM): A survey of manufactured products governed by EU Regulation using product definitions which are standardised across the EU to give comparability between Member States' data and the production of European aggregates at product level. Data is presented on both value (sales) and volume (units). The data is collected by the ONS.

Primary Products: Those products which are processed from raw materials to create the parent material for the construction of a vehicle. For example, ferrous and non-ferrous metals.

Small and Medium sized Enterprises (SMEs): Businesses employing less than 250 staff with a turnover of under £27m and with more than 25% owner-managed.

SMMT: The Society of Motor Manufacturers and Traders. SMMT provides services and support for the UK motor industry and organisations whose business is linked to the industry's activities.

Standard Industrial Classification (SIC): For use in classifying business establishments and other statistical units by the type of economic activity in which they are engaged. The classification provides a framework for the collection, tabulation, presentation and analysis of data and its use promotes uniformity.

Toxicity (human toxicity or ecotoxicity): Toxicity is used to describe the potential to cause harm to living organisms. This describes a number of adverse effects. For example, carcinogenic gaseous emissions are considered toxic. However, toxicity impacts are often difficult to describe with accuracy. This is due to the large degree of uncertainty in the data available that affects the development of toxicity impact assessment factors.

Human toxicity is used to describe the potential harm to humans from exposure to pollutants. Ecotoxicity is used to describe the potential harm to ecosystems from exposure to pollutants, but this is a very wide definition. Forbes & Forbes (1994) defined ecotoxicology as 'the field of study which integrates the ecological and toxicological effects of chemical pollutants on populations, communities and ecosystems with the fate (transport, transformation and breakdown) of such pollutants in the environment'.

WRAP: The Waste and Resources Action Programme. This organisation was established in 2001 in response to the UK Government's Waste Strategy 2000. Its purpose is to promote sustainable waste management, for example through research and awareness raising activities.

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PRODCOM PRA34100 (2000) *Motor Vehicles.*

PRODCOM PRA34201 (2000) *Bodies (coachwork) for motor vehicles (except caravans).*

PRODCOM PRA34202 (2000) *Trailers and semi-trailers.*

PRODCOM PRA34203 (2000) *Caravans.*

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Manufacturers' specification sheets

Various manufacturer's specification sheets were accessed in 2003 from the manufacturer web sites to define unladen weights for HGV vehicle classes. Those used were as follows:

● <3.5t	Ford Motor Company	Ford Transit 2.4TD
● 3.5-7.5t	MAN ERF UK Ltd	MAN L2000 8.155LRC
	Mercedes Benz	Mercedes Atego 815
● 7.5-18t	MAN ERF UK Ltd	MAN LE 220B
	Mercedes Benz	Mercedes Atego 1823
● 18-26t	MAN ERF UK Ltd	MAN ME 280B
	Mercedes Benz	Mercedes Actros 2531 LS
● 40t	Mercedes Benz	Mercedes Actros 1840 LS
● 44t	Mercedes Benz	Mercedes Actros 2543 LS

Appendix 1: Mass balance study concept and boundaries

For this study, the objective has been to identify resource flows in the UK motor industry for the year 2000. The flow of resources through manufacture into products to consumption and final disposal has been identified along with the associated transformation of resources into waste production and emissions.

The mass balance of the UK motor industry was divided into two parts:

- Mass balance for UK vehicle and component manufacture.
- Mass balance for UK vehicle use.

The two mass balances are linked in that:

- Fluids, components and vehicles produced in the former are used in the latter.
- Components available for reuse from ELVs in the latter form part of the available components in the former.

Figure 2.1 in the main body of the report has described the inputs and outputs used to calculate the mass balance for this study. The boundaries for each part of the mass balance are discussed in Table A1.1 and A1.2 respectively.

As with all studies of this type, in some cases it has not been possible to identify sources to provide data in the required format for the calculations required. For example, production data for components were sometimes only available as annual sales rather than as annual masses produced, which meant that a means was required to calculate the mass produced per annum. In these cases, assumptions and calculations were necessary to complete the mass balance calculations. Tables A1.1 and A1.2 summarise the main boundary issues affecting mass balance calculations and provide justification for the approach used. Further details are given Appendices 2 to 4.

In addition to data collected to complete the mass balance, in some categories additional data were presented in the report in order to give a fuller description of the resource flows in the industry. The tables also highlight these additional sources of data, but further details are given in Appendices 2 to 4.

Table A1.1 Data collected to complete the vehicle manufacturing mass balance and other resource flows in the UK motor industry

Issue	*Boundary*	*Further justification and comments on data availability*
Energy.	Energy used in production of vehicles and components was not included in the top level mass balance. Energy used for transport of components and vehicles moved in the industry was not included. These figures are included in the 'vehicles in use' component of the mass balance'.	Mass balance methodology excludes energy except for solid fuel use. Figures for tonnages of fuel used were not available, and in addition calculation of balancing emissions was beyond the scope of the study. Avoids double counting of energy demand.
Emissions to air.	Not included in the top level mass balance.	See above.
Primary products.	Included to quantify the different material products used in the motor industry.	Gives an indication of raw materials used, without including material flows which are the subject of other mass balance studies (e.g. iron, steel and aluminium are the subject of a mass balance completed by the University of Surrey Environmental Body*).
Components (Secondary products).	Includes components for vehicle assembly and aftermarket parts. Component imports calculated using proxy data. In addition to this, some of the production data not included.	No direct data on production weights. Data on certain products were not disclosed due to market sensitivity. It was not possible to calculate any information on the products with hidden data.
Vehicles.	Includes imports, exports and UK production in mass balance. Abandoned vehicles were included for interest, but did not form part of the top level mass balance study for the industry.	Do not form part of the mass balance because they do not leave the system. Included due to topical interest.
Waste from component and vehicle manufacture.	Included to illustrate arisings of production waste.	Calculated by allocation to SIC code from available Environment Agency data. The basis for this is discussed in Appendix 4.
Components used in aftermarket.	Required as input to the vehicle use mass balance (see Table A1.2).	Assuming that components arising as waste during maintenance are equal to components used during maintenance, then can be calculated by adding together the figures for waste components from maintenance and the components sold for reuse sourced from ELVs (see Table A1.2).
Fluids used in aftermarket.	Required as input to the vehicle use mass balance (see Table A1.2).	Assuming that fluids arising as waste during maintenance are equal to fluids used during maintenance, then this can be calculated by adding together the figures for waste fluids from maintenance and fluids lost during maintenance (see Table A1.2).
Special waste from production.	Included in mass balance as part of total mass of waste but not separately identified. Reported elsewhere.	Double counts total waste data from component and vehicle manufacture.

Stevens et al., 2004.

Table A1.2 Data collected to complete the vehicle use mass balance and other resource flows in the UK motor industry

Issue	*Boundary*	*Further justification and comments on data availability*
Energy.	The top level mass balance quantifies the mass of energy used for fuel in vehicles.Oxygen consumption during combustion and water vapour generated were included in the mass balance to enable the energy use input to balance with the emissions to air generated by fuel combustion.	Calculated from carbon/hydrogen ratios. Avoids double counting of energy demand.
Emissions to air.	Emissions to air generated during vehicle use were included. Oxygen consumption during combustion and water vapour generated were included in the mass balance to enable the energy use input to balance with the emissions to air generated by fuel combustion.	Calculated from carbon/hydrogen ratios. Avoids double counting of emissions to air.
Components and fluids used in aftermarket.	Components and fluids data were collected by conducting surveys with garages (see Appendix 2 and 3). Further calculations were then required. Mass of components for use in the aftermarket was calculated by adding the net component imports to components arising for reuse from ELVs. Similarly, the mass of fluids for use in aftermarket is the sum of the mass of waste fluids arising and fluids lost during maintenance and use.	It was not possible to obtain production weights directly for the components and fluids used in the aftermarket. Should include masses of parts used for modifications and accessories, but this was not possible due to a lack of available data.
Waste (ELVs)	Mass of ELV arisings calculated and included in the mass balance. Reuse, recovery and recycling activities only included for components.	Recycling and recovery activities would be part of other mass balance studies (see for example mass balance for polymers*).
Used vehicles leaving the parc.	This mass was calculated to represent all the used vehicles that never enter the ELV processing stream. This includes: ● Stolen, unrecovered vehicles. ● Legitimately exported used vehicles. ● Insurance frauds.	
Fluids lost.	Included in the mass balance to account for losses during use.	
Waste fluids and waste components (including tyres).	Accounts for wastes arising from maintenance activities. May underestimate component masses arising as they do not include aftermarket components used for reasons other than vehicle maintenance (e.g. modifications).	
Loss of tyre rubber.	Included to account for losses during tyre use.	

* *Waste Watch (2003). Plastics in the UK economy: a guide to polymer use and the opportunities for recycling. Waste Watch: London.*

Appendix 2: Data sources and confidence levels

For each of the data sources required in the study, a degree of confidence has been assigned to indicate the expected quality of the source. A colour coded key has been applied as follows:

High: Data recognised as being accurate and robust and for which sources can be established

Medium: Data based on expert judgement or assessment, not necessarily verifiable, or has been subject to analysis, but accepted by the Industry as being reasonable

Low: Best estimates made by the Project Team solely for the purpose of populating the database

For some parameters, no data were available from published sources, the Advisory Group or industry contacts. For this reason, further assumptions were sometimes necessary in order to calculate the required data. More detail on such assumptions made is given in the methodology used for calculations in Appendix 4.

Table A2.1 Data sources for primary products used in parts and vehicle manufacture

Indicator	*Source*	*Confidence*
Car composition	Care group	High
Light goods vehicle composition	Research paper	High
Heavy goods vehicle composition	Volvo truck	High
Bus composition	Volvo bus	High
Motorcycle composition	ACEM	High
Total mass of ferrous metal used for vehicles	ISS - personal communication	Medium
Total mass of aluminium used for vehicles	Aluminium Federation - personal communication	Medium
Total mass of copper used for vehicles	See methodology	Low
Total mass of zinc used for vehicles	See methodology	Low
Total mass of lead used for vehicles	See methodology	Low
Total mass of plastics used for vehicles	APME	Medium
Total mass of polymers used for vehicles	See Methodology	Low
Total mass of glass used for vehicles	WRAP	High
Total mass of rubber used for vehicles	UTWG	High
Total mass of fluids used for vehicles	See methodology	Low
Total mass of textiles used for vehicles	See methodology	Low
Total mass of other products used for vehicles	See methodology	Low

Table A2.2 Data sources used for components (secondary products)

Indicator	*Source*	*Confidence*
Total production mass of components produced for motor industry	ONS	Medium (some data were suppressed)*
Total imported mass of components produced for motor industry	ONS	Medium (some data were suppressed)*
Total exported mass of components produced for the motor industry	ONS	Medium (some data were suppressed)*

** Also see Section A3.5 for an account of reasons that these figures are expected to overestimate the mass of components by a small margin, due to inclusion of components used to produce or maintain caravans, trailers and specialist vehicles (SIC 34).*

Table A2.3 Data sources for vehicle manufacture

Indicator	*Source*	*Confidence*
Number of vehicles produced	SMMT	High
Number of vehicles exported	SMMT, MCIA, ONS	High
Number of vehicles imported	DTI	High
Mass of vehicles produced	See methodology	Low
Mass of vehicles imported	See methodology	Low
Mass of vehicles exported	See methodology	Low
New vehicle registrations over 5 years	SMMT	High
New production of vehicles over 5 years	SMMT	High

Table A2.4 Data sources for vehicle use and maintenance

Indicator	*Source*	*Confidence*
Life of component/fluids	Industry estimate	Medium
Number of components fitted	Industry estimate	Medium
Weight/volume of component	Industry estimate	Medium
Total miles travelled by vehicles	Transport statistics bulletin	Medium
Vehicles in use	SMMT	High
Miles travelled by vehicles per year	See methodology	Low
Miles travelled estimated by industry	Industry estimate	Medium
Number of components changed each year	See methodology	Low
Weight of disposal of components	See methodology	Low
Mass of components replaced each year	See methodology	Low
Density of fluid	Fluid companies	High
Parts replaced on vehicles over a year	Industry estimate	Medium
Tyre rubber lost during use	Hird (Viridis)	Medium
Waste oil arising	AEA	Medium

Table A2.5 Data sources for component recycling

Indicator	*Source*	*Confidence*
Steel reprocessing	Ian Goldsmith – Corus UK Steel Association	High
Plastics	Bumper Collect, SMMT	Medium
Glass	Autoglass, CARE	High, but quantity of material recycled small
Oil	SCCAEA Technology, DETR	High, but provides little information on oil arising from vehicles or maintenance separately
Batteries	Lead Development Association	High, but provides little information on vehicles or maintenance alone
Tyres	Used Tyre Working Group, ETRA	High

Table A2.6 Data sources for energy use

Indicator	*Source*	*Confidence*
Energy used by each economic sector	ONS from NETCEN	High
Matching ONS economic sector with SIC coding adopted throughout	See Methodology	Low
Percentage of contribution to the motor industry of other industries not included in SIC code 34	See Methodology	Low
Energy used in the whole of the UK	DTI	High
Energy used by all UK industry	DTI	High
Energy used in transport	DTI	High
Energy used by motor vehicles and the split by fuel type	NETCEN	High
Oxygen consumption during fuel combustion	Calculated using carbon/ hydrogen ratios derived from combustion equations: see methodology	Low
Water vapour produced during fuel consumption	Calculated using carbon/ hydrogen equations derived from combustion equations: see methodology	Low

Table A2.7 Data sources for emissions to air

Indicator	*Source*	*Confidence*
Emissions for each economic sector	ONS, NETCEN	High
Matching ONS economic sector with SIC coding adopted throughout	See methodology	Low
Percentage of contribution to the motor industry of other industries not included in SIC code 34	See methodology	Low
Selected emissions from road transport	NETCEN	High
Remaining road transport emissions	NETCEN	High
Traffic in vehicle km by vehicle type	DTI	High
Contribution from each vehicle type to total emissions	NETCEN	High

Table A2.8 Data sources for waste arisings

Indicator	*Source*	*Confidence*
Waste produced, by SIC code	EA waste benchmarking tool	Medium
Category of wastes produced: special, liquid, solid, sludge	EA waste benchmarking tool	Medium
Waste arisings as materials	EA waste benchmarking tool	Medium
Percentage of contribution to the motor industry of other industries not included in SIC code 34	See methodology	Medium
Number of businesses active in the UK and in sub-regions	ONS	High
Subdivision of ONS business bands to match EA size bands	See methodology	Low
Total arisings per sector	See methodology	Low
Arisings relevant to motor industry	See methodology	Low
Management of metallic waste arisings from SIC code 34	EA	High

Table A2.9 Data Sources for ELV Arisings

Indicator	*Source*	*Confidence*
Motor vehicles currently licensed: by body type: 1990-2000	DTLR	High
Vehicles currently licensed and unlicensed: 2000 with details of year of registration and most recent taxation activity	DTLR	High
Motor vehicles registered for the first time: by taxation group: 1990-2000	DTLR	High
Motor vehicles licensed by taxation class – GOR, MC and Country: 2000	DTLR	High
Motor vehicles registered for the first time with related stock and ownership information- GOR, MC and Country: 2000	DTLR	High
LGVs first registered in 2000, by area of registered keeper	DTLR	High
LGV stock at end of 2000, by area	DTLR	High
New registrations in 2000, by class and body type	DTLR	High
Motor vehicles currently licensed: by taxation group 1999 and area	DTLR	High
Exports of components and vehicles	ONS	High
Recovery rate for stolen vehicles	Home Office	Medium
Number of stolen vehicles (England and Wales)	Home Office	High
Estimated percentages of vehicles stolen and not recovered following each pathway (broken for parts/ insurance fraud/ ringing/ export)	Home Office	Medium
Number of stolen vehicles (Scotland)	ONS	High
Recovery rate for stolen Vehicles England and Wales (used instead of figure directly from Home Office)	TRL Limited	High
Stolen vehicles and estimated recovery rate (N Ireland)	Northern Ireland Police	Medium
Estimated recovery rate for stolen vehicles in Scotland	Strathclyde Police	Medium
Vehicles currently registered by body type: 1996-2000 (Northern Ireland)	Department for Regional Development, Northern Ireland (Central Statistics and Research Branch)	High
Motor Vehicles registered for the first time in NI by vehicle type (Northern Ireland)	Department for Regional Development, Northern Ireland (Central Statistics and Research Branch)	High
Cars registered for the first time in NI by Make: 2000 (Northern Ireland)	Department for Regional Development, Northern Ireland (Central Statistics and Research Branch)	High
Cars registered for the first time in NI by Make: 2000 (Northern Ireland)	Department for Regional Development, Northern Ireland (Central Statistics and Research Branch)	High
Average age of vehicle	ONS	High
Estimated % unlicensed (GB)	DVLA	Medium
Estimated % unlicensed (N Ireland)	DVLNI	Medium
Parts removed for reuse and recycling and their weights	Overton dismantlers*	Medium
Components resold/ recycled	Other dismantlers	Medium
Mass of statutory ELVs	See methodology	Low
Mass of non-statutory ELVs	See methodology	Low
Abandoned cars/ LGVs	Local authority survey*	High
Abandoned HGVs, buses, motorcycles	Assumed none arise based on personal communication with dismantler	Low

** Published in Kollamthodi et al., 2003a*

Table A2.10 Data sources for ELV processing

Indicator	*Source*	*Confidence*
Depollution activities	Dismantlers	Low
Parts removed for reuse	Dismantlers	Low
Material reuse, recycling at dismantlers	ELV processing study*	Low
Material recovery at shredders	ELV processing study* BMRA	High High
Disposal of material from shredders	ELV processing study*	Medium

** Published in Kollamthodi et al., 2003a*

Appendix 3: SIC codes used to define motor industry activities

A3.1 Defining the motor industry

Throughout, SIC codes have been used as a basis to gather data on resource use, as a standard means of describing industrial activities in the motor industry.

In this report, products included in the motor industry comprise those resulting from:

- Standard Industrial Classification (SIC) 34, which describes the manufacture of motor vehicles and parts of motor vehicles[1].
- SIC 35.41, which describes the manufacture of motorcycles.
- First tier components manufactured in a wide range of industrial activities[2].

Sections A3.2 and A3.3 describe the sources of data used to describe the resource use of motor industry activities. However, further calculations using the data were required to:

- Prevent double counting in SIC 34 data.
- Allocate mass of components to the motor industry in a consistent manner.

Section A3.4 and A3.5 describes how this was achieved in the project.

A3.2 Relationship between SIC codes and PRODCOM Data

SIC categories correspond directly to most of the higher level classifications given in the PRODCOM (PRODuction COMmunautaire) List, the common basis by which industrial production statistics are collected throughout the European Union, both classifications being based on the NACE Rev.1 classifications (Statistical Classification of Economic Activities in the European Community).

The 2001 PRODCOM List, which was completed in September 2000, is based on the more extensive European Union external trade nomenclature, the 2001 Combined Nomenclature (CN) which came into force in January 2001. The Combined Nomenclature has been proposed by Forum for the Future as the common basis for the presentation of quantitative data collected under the Biffaward Mass Balance programme of studies.

The PRODCOM List identifies unique classifications for products together with a description of the product and, where appropriate, a listing of the corresponding CN classifications where these have been aggregated into the PRODCOM classification. This study has adopted the PRODCOM list as this is the basis on which the majority of data required was available in this format.

A3.3 Relationship of SIC codes to industrial sectors in ONS environmental accounts

Production data for the industry has been obtained mainly from the Office of National Statistics (ONS) PRODCOM, using SIC classification codes. For information about wastes, emissions and energy use, SIC codes were not always given. For this reason, the SIC codes used to describe motor industry activities needed to be matched with codes used to describe industrial sectors in other data sources. For example, the main categories used for sourcing data from the ONS statistics were:

- Sector 47 for the Environmental Accounts, which is the manufacture of motor vehicles and parts of motor vehicles (ONS, 2003a).
- SIC $^{(92)}$ 34 for PRODCOM data.

These two sources are directly comparable in terms of the activities they describe. It was possible to make similar analogies between the data required for other SIC codes used to describe motor industry activities in the study.

A3.4 Data calculations to allocate resource use consistently to industrial sectors outside SIC 34

Although industrial sector SIC 34 includes many of the UK motor industry activities, it does not capture all of the first tier component suppliers for the motor industry and does not include motorcycles. It is necessary to incorporate certain proportions of a number of other economic sectors to establish their contribution towards the motor industry.

For example, within SIC (92) 26 (manufacture of glass and glass products), there are three PRODCOM categories that relate to the manufacture of vehicles. Table A3.1 shows how the percentage of SIC (92) 26 that is accounted for by these three categories can be calculated using proxy economic data. This approach was extended to

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[1] *This report excludes activities related to caravans and trailers.*

[2] *See Table A3.2 for a list of the 2 digit SIC codes describing these activities.*

calculate the contribution made by mass to the motor industry for other first tier component suppliers in economic sectors other than those activities covered by SIC code 34.

Table A3.1 Percentage of SIC 26.1 used in vehicle manufacture using proxy economic data

SIC/ PRODCOM	*Description*	*UK manufacturing sales (£000)*
26.1	Glass and glass products (SIC 26.1)	2,293,423
26.12.12.15	Toughened safety glass for use in motor vehicles	8,338
26.12.12.55	Laminated safety glass for use in motor vehicles	6,777
26.12.13.50	Glass rear-view mirrors for vehicles	2,057
Total		17,173
Percentage of SIC 26.1 that relates to vehicle manufacture		0.75%

Table A3.2 provides a breakdown of the different SIC codes which provide components and other resources for the motor industry using this approach. The column entitled '% included in Motor Industry' provides a best estimate for the contribution to the motor industry of each of these economic sectors. The Advisory Group for the project were asked to comment on this, providing support to the project team by providing the benefit of their fuller understanding or indicating where superior information was available. The data were required to ensure completeness and consistency in calculating resources used in the study.

Table A3.3 describes the 4-digit SIC codes used to describe activities in the UK motor industry. Table A3.4 describes some of the more detailed 8-digit SIC codes used to describe the contribution made by first tier component manufacturing activities to the UK motor industry.

Table A3.2 Estimated proportions of the mixed economic sectors to the vehicle industry

SIC	*Economic sector*	*Proportion included in motor industry*
17	Textiles	7%
19	Leather	<1%
24.3	Paints, varnishes, printing inks etc.	10%
25.1, 25.2	Rubber and plastic products	8%
26	Glass and glass products	<1%
27	Casting of metal	19%
28	Metal products	3%
31	Electrical machinery	9%
32	Radio, television and communications	<<1%
35.41	Motorcycles	100%

A3.5 Inconsistency in boundaries for including data for SIC 34

The report has taken as its subject motor vehicles including:

- Cars and taxis.
- Light goods vehicles (LGVs).
- Heavy goods vehicles (HGVs).
- Buses and coaches.
- Motorcycles.

It was not possible to include industrial activities relating to caravans, trailers and specialist vehicles (e.g. tractors) in the study, because there were no available data to calculate the contribution by mass of these items to the motor industry.

However, it has not proved possible to separately identify the following and remove the following from the data collected in the mass balance, to achieve consistency in reporting masses of products:

- Components used to produce caravans, trailers and specialist vehicles (SIC 34).
- Components used for the maintenance of caravans, trailers and specialist vehicles (SIC 34).

For this reason, the masses allocated to the production of components for the motor industry as defined in this research will tend to be an overestimate.

Similarly, the data used to quantify air emissions and energy use for SIC 34 are quoted for all motor industry manufacturing activities, including the manufacture of caravans, trailers, specialist vehicles and their constituent parts. For this reason, these figures are likely to overstate the air emissions and energy used in production. However, given that the use of vehicles included makes the largest contribution towards the totals calculated in this research for the year 2000, it is not anticipated that this will have significantly affected the results obtained.

Table A3.3 List of four digit SIC codes used in the study

- 17 MANUFACTURE OF TEXTILES
  - 17.1 Preparation and spinning of textile fibres
    - *17.11 Preparation and spinning of cotton-type fibres*
    - *17.12 Preparation and spinning of woollen-type fibres*
    - *17.13 Preparation and spinning of worsted-type fibres*
    - *17.14 Preparation and spinning of flax-type fibres*
    - *17.15 Throwing and preparation of silk including from noils and throwing and texturing of synthetic or artificial filament yarns*
    - *17.16 Manufacture of sewing threads*
    - *17.17 Preparation and spinning of other textile fibres*
  - 17.2 Textile weaving
    - *17.21 Cotton-type weaving*
    - *17.22 Woollen-type weaving*
    - *17.23 Worsted-type weaving*
    - *17.24 Silk-type weaving*
    - *17.25 Other textile weaving*
  - 17.3 Finishing of textiles
    - *17.30 Finishing of textiles*
  - 17.4 Manufacture of made-up textile articles, except apparel
    - *17.40 Manufacture of made-up textile articles, except apparel*
  - 17.5 Manufacture of other textiles
    - *17.51 Manufacture of carpets and rugs*
    - *17.52 Manufacture of cordage, rope, twine and netting*
    - *17.53 Manufacture of non-wovens and articles made from non-wovens, except apparel*
    - *17.54 Manufacture of other textiles not elsewhere classified*

- 19 TANNING AND DRESSING OF LEATHER; MANUFACTURE OF LUGGAGE, HANDBAGS, SADDLERY, HARNESS AND FOOTWEAR
  - 19.1 Tanning and dressing of leather
    - *19.10 Tanning and dressing of leather*

- 24 MANUFACTURE OF CHEMICALS AND CHEMICAL PRODUCTS
  - 24.3 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
    - *24.30 Manufacture of paints, varnishes and similar coatings, printing ink and mastics*

- 25 MANUFACTURE OF RUBBER AND PLASTIC PRODUCTS
  - 25.1 Manufacture of rubber products
    - *25.11 Manufacture of rubber tyres and tubes*
  - 25.2 Manufacture of plastic products
    - *25.24 Manufacture of other plastic products*

Continued ....

Table A3.3 (Continued) List of four digit SIC codes used in the study

Subsection DI MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS

- 26 MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS
  - 26.1 Manufacture of glass and glass products
    - *26.12 Shaping and processing of flat glass*
  - 26.2 Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products

- 27 MANUFACTURE OF BASIC METALS
  - 27.5 Casting of metals
    - *27.51 Casting of iron*
    - *27.52 Casting of steel*

- 28 MANUFACTURE OF FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT
  - 28.4 Forging, pressing, stamping and roll forming of metal; powder metallurgy
    - *28.40 Forging, pressing, stamping and roll forming of metal; powder metallurgy*

- 31 MANUFACTURE OF ELECTRICAL MACHINERY AND APPARATUS NOT ELSEWHERE CLASSIFIED
  - 31.4 Manufacture of accumulators, primary cells and primary batteries
    - *31.40 Manufacture of accumulators, primary cells and primary batteries*
  - 31.6 Manufacture of electrical equipment not elsewhere classified
    - *31.61 Manufacture of electrical equipment for engines and vehicles not elsewhere classified*

- 32 MANUFACTURE OF RADIO, TELEVISION AND COMMUNICATION EQUIPMENT AND APPARATUS
  - 32.3 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods
    - *32.30 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods*

Continued ....

Table A3.3 (Continued) List of four digit SIC codes used in the study

34	MANUFACTURE OF MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS
34.1	Manufacture of motor vehicles
34.10	*Manufacture of motor vehicles*
34.2	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
34.20	*Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers*
34.20/1	*Manufacture of bodies (coachwork) for motor vehicles (except caravans)*
34.3	Manufacture of parts and accessories for motor vehicles and their engines
34.30	*Manufacture of parts and accessories for motor vehicles and their engines*
35	MANUFACTURE OF OTHER TRANSPORT EQUIPMENT
35.4	Manufacture of motorcycles and bicycles
35.41	*Manufacture of motorcycles*

Table A3.4 Additional PRODCOM classifications relating to first tier materials and products

NB: Only a proportion of each SIC code was considered to contribute directly to the UK motor industry (see Table A3.2)

PRODCOM reference	*Description*	*PRODCOM reference*	*Description*
25.11.11.00	New pneumatic rubber tyres for motor cars INCLUDING: for racing cars.	27.51.13.40	Grey iron castings for internal combustion piston engines, bearing housings incorporating ball or roller bearings, gears, gearing, clutches, universal joints and shaft magnetic clutches.
25.11.12.35	Pneumatic rubber tyres for motorcycles and scooters with rims exceeding 13 inches (33cm) in diameter.	27.52.10.10	Steel castings for land vehicles excluding for locomotives or rolling stock or construction industry vehicles.
25.11.12.37	Pneumatic rubber tyres for motorcycles and scooters with rims not exceeding 13 inches (33cm) diameter.	27.52.10.40	Steel castings for internal combustion piston engines, transmission shafts, camshafts, crankshafts, cranks, bearing housings incorporating ball or roller bearings, gears, gearings, ball screws, torque converters, gearboxes and other speed changers, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings, excluding for hoists or electromagnetic clutches.
25.11.13.55	New pneumatic rubber tyres for buses or lorries with a load index not exceeding 121*.	28.40.11.33	Open die forged ferrous parts for transmission shafts, camshafts, crankshafts and cranks.
25.11.13.57	New pneumatic rubber tyres for buses or lorries with a load index exceeding 121*.	28.40.11.35	Open die forged ferrous parts for machinery and mechanical appliances, electrical machinery and equipment, locomotives or rolling stock, rail/ tramway track fixture and fittings, mechanical signalling, safety or traffic control equipment, land vehicles, aircraft, satellites, spacecraft and launch vehicles.
25.11.13.73	Rubber inner tubes for motor cars, buses or lorries.	28.40.11.51	Cold Extrusion steel parts for land vehicles Excluding: for locomotives or rolling stock, straddle carriers, works trucks fitted with lifting or handling equipment, agricultural rollers, road rollers, bulldozers and the like, shopping trolleys.
25.11.15.77	Rubber inner tubes for motorcycles or scooters.	28.40.11.53	Cold extrusion steel parts for internal combustion piston engines, bearing housings, plain shaft bearings, gears, gearing, ball screws, torque converters, gearboxes and other speed changers, flywheels, pulleys, pulley blocks, clutches, universal joints and couplings.
25.11.16.00	'Camel-back' strips for retreading rubber tyres.	28.40.11.57	Cold extrusion steel parts for locomotives or rolling stock, track fixtures and fittings, mechanical signalling, safety or traffic control equipment, tractors and motor vehicles, all types of optical, photographic, cinematographic, measuring, checking and building industry.
25.24.90.60	Plastic parts and accessories for all land vehicles: excluding for locomotives or rolling stock.	28.40.11.58	Cold extrusion non-ferrous metal parts for machinery and mechanical appliances, electrical machinery and equipment, optical, photographic, cinematographic, measuring, locomotives or rolling stock, track fixtures and fittings, mechanical tractors, motor vehicles, all types of aircraft, satellites, spacecraft and their launch vehicles.

Continued ....

Table A3.4 (Continued) Additional PRODCOM classifications relating to first tier materials and products

NB: Only a proportion of each SIC code was considered to contribute directly to the UK motor industry (see Table A3.2)

PRODCOM reference	*Description*	*PRODCOM reference*	*Description*
26.12.12.15	Toughened safety glass for use in motor vehicles.	28.40.12.10	Drop forged (and precision forged) steel parts for land vehicles EXCLUDING: locomotives and rolling stock.
26.12.13.50	Glass rear-view mirrors for vehicles.	28.40.12.30	Drop forged (and precision forged) steel parts for internal combustion piston engines, bearing housings incorporating ball or roller bearings, gears and gearing, ball changers, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings.
27.51.11.10	Malleable iron castings for land vehicles EXCLUDING: for locomotives or rolling stock, construction industry vehicles.	28.40.13.10	Sheet metal forming of steel as parts for land vehicles EXCLUDING: locomotives and rolling stock.
27.51.11.40	Malleable iron castings for internal combustion piston engines, for transmission shafts, camshafts, crankshafts, cranks, bearing housings incorporating ball or roller bearings, gears, gearing, ball screws, torque converters, gearboxes and other speed changers, flywheels, pulleys, pulley blocks, clutches universal joints and shaft couplings.	28.40.13.20	Sheet metal forming of steel as parts for internal combustion piston engines, transmission shafts, crankshafts, camshafts and cranks, bearing housings, plain shaft bearings, gears, gearing, ball screws, torque converters, gearboxes and other speed changers, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings.
27.51.12.10	Ductile iron castings for land vehicles EXCLUDING: for piston engines, lifting or handling machinery, construction industry machinery/vehicles.	28.40.20.10	Steel powdered metallurgy parts for land vehicles EXCLUDING: for locomotives and rolling stock.
27.51.12.40	Ductile iron castings for internal combustion piston engines, for bearing housings incorporating ball or roller bearings, gears, gearing, ball screws, torque converters, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings.	28.40.20.20	Steel powdered metallurgy parts for bearing housings and plain shaft bearings EXLCUDING:- bearing housing with ball or roller bearings.
27.51.13.10	Grey iron castings for land vehicles EXCLUDING: for locomotives or rolling stock, construction industry vehicles.	28.40.20.30	Steel powdered metallurgy parts for internal combustion piston engines, transmission shafts, camshafts, crankshafts, cranks, bearing housings incorporating ball or roller converters, gearboxes and other speed changers, flywheels, shaft couplings; for pumps or liquids.
27.51.13.40	Grey iron castings for internal combustion piston engines, bearing housings incorporating ball or roller bearings, gears, gearing, clutches, universal joints and shaft magnetic clutches.	31.61	Electrical equipment for vehicles and engines.
27.52.10.10	Steel castings for land vehicles excluding for locomotives or rolling stock or construction industry vehicles.	31.40.21.10	Lead-acid accumulators for starting piston engines, of a weight not exceeding 5kg, working with liquid electrolyte.

Continued ....

Table A3.4 (Continued) Additional PRODCOM classifications relating to first tier materials and products

NB: Only a proportion of each SIC code was considered to contribute directly to the UK motor industry (see Table A3.2)

PRODCOM reference	*Description*	*PRODCOM reference*	*Description*
27.52.10.40	Steel castings for internal combustion piston engines, transmission shafts, camshafts, crankshafts, cranks, bearing housings incorporating ball or roller bearings, gears, gearings, ball screws, torque converters, gearboxes and other speed changers, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings, excluding for hoists or electromagnetic clutches.	31.40.21.30	Lead-acid accumulators for starting piston engines, of a weight not exceeding 5kg, EXCLUDING: working with liquid electrolyte.
28.40.11.33	Open die forged ferrous parts for transmission shafts, camshafts, crankshafts and cranks.	31.40.21.50	Lead-acid accumulators for starting piston engines, of a weight exceeding 5kg, working with liquid electrolyte.
28.40.11.35	Open die forged ferrous parts for machinery and mechanical appliances, electrical machinery and equipment, locomotives or rolling stock, rail/ tramway track fixture and fittings, mechanical signalling, safety or traffic control equipment, land vehicles, aircraft, satellites, spacecraft and launch vehicles.	31.40.21.70	Lead-acid accumulators for starting piston engines, of a weight exceeding 5kg, EXCLUDING:- working with liquid electrolyte.
27.51.12.40	Ductile iron castings for internal combustion piston engines, for bearing housings incorporating ball or roller bearings, gears, gearing, ball screws, torque converters, flywheels, pulleys, pulley blocks, clutches, universal joints and shaft couplings.	31.40.22.10	Lead-acid traction accumulators working with liquid electrolyte.
27.51.13.10	Grey iron castings for land vehicles EXCLUDING: for locomotives or rolling stock, construction industry vehicles.	31.40.22.30	Lead-acid traction accumulators EXCLUDING working with liquid electrolyte.
		32.30.12.70 + 90	Car radios.

** The LOAD INDEX is a numerical code associated with the maximum load a tyre can carry at the speed indicated by its Speed Symbol under service conditions specified by E.T.R.O 1991, passenger car tyres section 13.*

Appendix 4: Details of methodology

A4.1 Calculations used for resource use (products)

A4.1.1 Primary products

The total mass of primary products used for the manufacture of components and vehicles was sourced from the relevant trade associations. Information was available directly for ferrous metal (ISS), aluminium (Aluminium Federation), zinc (IZA), plastics (APME), other polymers (BPF), glass (WRAP), rubber (BPF), lead (Non-Ferrous Alliance) and copper (Non-Ferrous Alliance). An estimate for the mass of remaining primary products were calculated based on the percentage by weight of the product input to vehicles (using the density where only volumes were available). These figures are presented in Table A4.1.

Table A4.1 Proportion of primary products used in manufacturing activities

Primary Product	*Proportion (%)*	*Total mass input (kt)*
Ferrous metal	58.8	2,350
Non-ferrous metal (aluminium, copper, zinc, lead)	5.7	227
Plastics	19.0	750
Glass	1.2	49
Rubber	2.7	105
Fluids*	4.0	159
Textiles*	3.5	141
Other*	5.4	216
Total	100.0	3,997

** Calculated on the basis of percentage by weight in vehicles. The remaining data sourced from trade associations.*

Sources: ISS, 2003; Aluminium Federation, 2003; IZA, 2003; APME, 2003; BPF, 2003; WRAP, 2000; BPF, 2003; Non-Ferrous Alliance, 2002; UTWG, 2003.

A4.1.2 Components

Components produced in the UK for vehicle assembly and aftermarket

PRODCOM data (ONS, 2001c) describe the mass, volume and sales of items produced, classified by industrial activity (see Appendix 3). For some activities, the mass of items was not available, but this was still the best available data. In order to convert these data sources into masses, it was necessary to determine the average weight of each item. In most cases the item data were available as pounds sterling per individual item and pounds sterling per kilogram. In some cases, this level of detail was only available for export data. In these circumstances the mass was calculated based on £/item using export figures for that particular component.

The following formula was used to calculate the total mass of each product:

$$kg\,/\,item = \frac{\pounds\,/\,item}{\pounds\,/\,kg}$$

Where £/*item* is taken from UK sales and £/*kg* is taken from product exports

For example, to calculate the mass of bumpers in 2000, the following calculation was performed.

Cost per bumper item in 2000	=	£32.35/*item*
Cost per kg exported in 2000	=	£5.24/*kg*
Therefore, mass per item	=	32.35/5.24 = 6.173 *kg/item*
The total mass of bumpers for use in the aftermarket	=	(*kg/item*) × no. of bumpers
	=	279,126 × 6.173
	=	1,723,044 *kg*

It was necessary to separate the mass of components used in vehicle assembly from the mass of aftermarket components in order to avoid double counting of components within the total mass of vehicles produced. In all cases, aftermarket and assembly figures were available separately for UK production because of the way the data are reported in PRODCOM.

Imported components for vehicle assembly and aftermarket

The mass of components manufactured outside the UK and imported for vehicle assembly and aftermarket use in 2000 were presented in kilograms in the PRODCOM data. The figures were not separated into those imported for aftermarket and assembly, so an estimate of 75% by mass was used to allocate masses to components for assembly and 25% for the aftermarket.

Exported components for vehicle assembly and aftermarket

The mass of components exported from the UK in 2000 was presented in kilograms in the PRODCOM data. The percentage of the sales of exported components for aftermarket and assembly was used to calculate the mass of components exported for use in the aftermarket and assembly from the aggregated total.

Where data were missing from the PRODCOM categories, they were not included in the study because no alternative data sources were available. This is applies to the categories shown in Table A4.2.

A4.1.3 Vehicle manufacture

Passenger cars and LGVs make up a majority of the vehicle parc so it was important to determine their mass most accurately. However, the collection and analysis of data for the other vehicle types included within the definition of the UK motor industry has required the development of different methods to identify both information sources and analytical techniques.

The class categories for HGVs and Buses have been used as a basis for vehicle mass. However, data used from SMMT listed only gross vehicle weights for these vehicles, and it was necessary to establish an average unladen weight for each vehicle class. This has been achieved by consultation with industry bodies and the resulting unladen weights used in the study are listed in Table A4.3.

In order to calculate estimates of the masses of vehicles produced, imported and exported, it was necessary to determine the number of vehicles in each class produced, imported and exported (see Table A4.4). The number of vehicles in each vehicle class, together with the unladen weights described were used to estimate the mass of vehicles produces during 2000.

A4.2 Calculations of emissions to air

A4.2.1 Introduction

The main data sources for the air emissions reported have been:

- DEFRA/ONS Digest of Environmental Statistics (ONS/DEFRA, 2003).
- ONS Environmental Accounts (ONS, 2003a), time series spreadsheet D5692.

Table A4.3 Vehicle masses used in calculations for new vehicles

Vehicle type *Models*	*Unladen weight (Tonnes)*	*Source*
Car		
–	1.035	Kollamthodi *et al.*, 2003a.
LGVs		
–	1.405/1.750	Kollamthodi *et al.*, 2003a.
HGVs		
3.5t - 7.5t	3.385	Manufacturers specification sheets, 2003.
7.5t-12t	4.000	
12t-25t	5.503	
25t-33t	7.507	
33t – 38t	7.500	
>38t	6.915	
Bus		
Touring coach	13.250	SMMT, 2000.Volvo Bus, 2003.
Double deckers	11.250	
Single deckers	10.700	
Midibuses	8.500	
Minibuses	3.500	
Motorcycles		
Scooter	0.100	MCIA, 2003.
Trail/enduro	0.120	
Traditional	0.180	
Sport/Touring	0.180	
Supersport	0.170	
Touring	0.240	
Custom	0.280	
Adventure sport	0.250	
Moped scooter	0.850	
Moped other	0.850	

Table A4.4 Sources for vehicle numbers used in calculations for imports, exports and production of new vehicles

Vehicle Type	*Source of information on vehicles numbers*
Car	SMMT, 2000
LGVs	SMMT, 2000
HGVs	SMMT, 2000
Buses and coaches	SMMT, 2000, Volvo bus, 2003
Motorcycles	MCIA, 2003

Table A4.2 Unavailable PRODCOM data

SIC Code	*Details*	*Status*
31.61.00.01	Electrical lighting or visual signalling equipment for the original production of motor vehicles INCLUDING: - original equipment (OE) spares.	No data
31.61.00.03	Electrical sound signalling equipment for the original production of motorcycles or motor vehicles INCLUDING: -original equipment (OE) spares	No data
31.61.00.05	Windscreen wipers, defrosters and demisters for the original production of motor vehicles INCLUDING: - original equipment (OE) spares	Data incomplete
31.61.21.30	Sparking plugs	Data incomplete

- NETCEN UK Greenhouse Gas Inventory 1990 to 2001: Annual Report for submission under the Framework Convention on Climate Change (NETCEN, 2003a).

All of the sources are linked to the work undertaken to create the UK National Atmospheric Emissions Inventory (NAEI) for air pollution. When necessary, the data have been allocated to vehicle classes and contributions of production activities to the motor industry. This has used data from Transport Statistics (ONS/ DfT, 2002) and from PRODCOM reports related to relevant SIC codes (ONS, 2001). This was necessary to give an indication of the contribution of each motor vehicle type and SIC industrial sector towards the total emissions quoted.

The data sources and the methodology adopted are described in the following sections.

A4.2.2 Data sources

The NAEI is funded by DEFRA, The National Assembly for Wales, The Scottish Executive and The Department of Environment, Northern Ireland. This compiles estimates of emissions to air from UK sources. In this report, those emissions from transport sources were of most interest. These emissions are estimated to help to find ways of reducing the impact of human activities on the environment and human health in the UK.

Since 1995, one of the main activities of the NAEI is the production of the annual National Inventory on emissions (NETCEN, 2003a is the version used in this report). This is submitted each year under the United Nations Framework Convention on Climate Change (UNFCCC).

A4.2.3 Calculations

The emissions data available from the Environmental Accounts time series, collected in the summary spreadsheet D5692 (ONS, 2003a), are presented by main economic sectors (up to 93 sectors). The emissions reported relate to direct emissions only and as such do not include any emissions resulting from National Grid energy usage[1]. The coding adopted in Environmental Accounts for describing the main economic sectors do not follow the SIC (92) codes but can be directly related to them. Table A4.5 illustrates how ONS economic sectors were matched to SIC codes in the study.

Figures for emissions due to product and material manufacture were calculated by breaking down ONS emissions data by industry sectors according to manufacturing sales statistics (or employment, for SIC 35.4) using the percentages in Table A4.6.

It is acknowledged that this is not an ideal method to calculate emissions to air. Some difficulties include:

- The methodology assumes that emission generation is consistent across all industries.
- The methodology assumes that value or employment is proportional to emissions generated.
- Not all products are traded.
- The sales data was not complete.

As the use phase of the motor industry includes the transport of goods and materials within the industry itself, the transportation of goods in the industry has not been evaluated separately to avoid double counting.

A4.2.4 Use phase

The contribution of road transport to air emissions is subject to continuous monitoring and study. The NETCEN Inventory has been used to supply data on the main types of air emissions studied.

Table A4.5 ONS economic sectors and SIC (92) codes used

ONS' economic sectors	*SIC (92) code*
10 Textiles	SIC code 17.5 Textiles
30 Rubber products	SIC code 25.1 Rubber and rubber products
31 Plastic products	SIC code 25.2 Plastic and plastic products
32 Glass and glass products	SIC code 26.1 Glass
40 Metal castings	SIC code 27.5 Casting of metals
41 Metal products	SIC code 28.4 Fabricated metal products
44 Electrical machinery	SIC code 31.6 Electrical equipment
45 Radio, television and communications	SIC code 32.3 Radio
47 Motor vehicles	SIC code 34: Manufacture of motor vehicles and parts
48 Other transport equipment	SIC code 35.4 Motorcycles

Sources: ONS 2001c.

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[1] *Refer to Chapter 6 Energy usage for details of electricity use.*

Table A4.6 Contribution of the various SIC codes to the motor industry

SIC(92) code	*Contribution*
SIC code 17.5 Textiles	7.00%
SIC code 25.1 Rubber and rubber products	8.00%
SIC code 25.2 Plastic and plastic products	1.00%
SIC code 26.1 Glass	1.00%
SIC code 27.5 Casting of metals	19.00%
SIC code 28.4 Fabricated metal products	3.00%
SIC code 31.6 Electrical equipment	9.00%
SIC code 32.3 Radio	0.01%
SIC code 34: Manufacture of motor vehicles and parts	100%
SIC code 35.4 Motorcycles	0.26%*

** Employment share of the SIC code 35 'Other transport equipment'.*

Detailed data on emissions of carbon monoxide, benzene, methane, carbon dioxide, NO_x, NMVOC and PM10 are reported for the year 2000 by vehicle classes in the NAEI. This is based on the emissions from different vehicle types and the distance travelled by each vehicle type during 2000. A number of factors have been taken into account in the annual emissions quoted for each vehicle type, including a consideration of variations due to urban, rural and motorway driving. Further details of the calculation methods are given on NAEI Website (www.naei.org.uk). The base data in NETCEN are also used by ONS and Transport Statistics (DfT/ONS, 2002). For example, the distances travelled in 2000 are presented in Table A4.7.

Table A4.7 Traffic by vehicle type (from Transport Statistics), in billion vehicle km in 2000

	Cars/ taxis	*Motor -cycles*	*Buses and coaches*	*Light vans*	*Goods vehicles*	*All motor vehicles*
All roads	379	4.4	4.8	50.5	29.3	467.7

Source: DfT, 2002b.

A4.3 Energy data calculations

A4.3.1 Introduction

Chapter 6 presents data on the amount of energy used by the motor industry in 2000. Calculations for this section were based on data presented in:

- ONS/DTI Digest of Energy Statistics (ONS/DTI, 2003 and 2001 versions).
- ONS Environmental Accounts (ONS, 2003a) Time series spreadsheet D5692.
- NETCEN UK Greenhouse Gas Inventory 1990 to 2001: Annual Report for submission under the Framework Convention on Climate Change (NETCEN, 2003), background data.

Data for the whole of the UK were allocated to the motor industry on the basis of the relative magnitude of economic data, for production of vehicle and parts and first tier manufacturers. For the transport phase, data were readily available from ONS and NETCEN as fuel consumed by each type of vehicle. The transport of materials and goods within the UK motor industry, including for maintenance activity, is part of the use phase and therefore it has not been analysed separately, thus avoiding double counting.

A4.3.2 Data sources and calculations

The energy used for the manufacturing stage was obtained by using ONS Environmental Accounts data (ONS, 2003a), used also for the calculation of the emissions to air. The same methodology described in the previous section was therefore used.

The energy data, collected by NETCEN for the production of emissions estimates, are presented in tonnes of oil equivalent (toe) and include the net electricity usage, i.e. the difference between energy sourced from the National Grid and electricity generated by the factories during their industrial processes (used and/or fed back to the grid). Energy from the National Grid is not included in this study.

Presentation of data in the report includes energy used in Mtoe for production of vehicles and components in the UK including component manufacture. The allocation of energy in sectors outside SIC 34 has been apportioned based on economic data for component manufacture. It is preferable to allocate based on mass rather than economic data. However, data were not available on masses of components.

It is acknowledged that this is not an ideal method to calculate energy consumption. Problems include:

- The methodology assumes that energy consumption is consistent across all industries.
- Not all products are traded.
- The sales data was not complete.

It must be noted that products excluded from the definition of the motor industry to avoid double counting on the production phase still consume energy in their manufacture and have therefore been accounted for in the energy (and emissions) calculation. The energy figures presented for product and material manufacture do not include any energy used in the processing of reused/recycled/reclaimed materials.

The ONS spreadsheet (ONS, 2003a) and the DTI data (ONS/DTI, 2001 and 2003) do not allow for a detailed estimate of the fuel used by the road transport. NETCEN background data for the NAEI (NETCEN, 2003; NAEI, 2003) are the original sources of data for the ONS spreadsheet. For this reason, they were used in road transport calculations, since the fuel consumption for each vehicle type was readily available.

ONS/DTI digest of energy statistics (2003 and 2001 editions) present historical data on energy production and consumption in the UK, with relevant comments on the trends for each year included. Data on fuel consumption for road transport are also reported, which is of the same order of magnitude as the NETCEN data. It was found that there was a 2Mtoe difference between the data sources. The 2Mtoe difference may be due to rounding and/or the different sources of information used. Also, the DTI acknowledge in the Digest of Energy Statistics that 'the consistency of the classification across different commodities cannot be guaranteed because the figures reported are dependent on what the data suppliers can provide' (DTI, 2001).

A4.3.3 Oxygen consumption and water vapour generated during fuel combustion

For the vehicle use stage of the mass balance, it has been necessary to calculate the oxygen consumed and water generated during the direct combustion of fuels by vehicle engines in order to balance the mass of fuel consumed. This has been possible by using factors calculated from fuel combustion equations (based on carbon/ hydrogen ratios) to establish the oxygen demand. These calculations were carried out using factors calculated and used in a previous mass balance study on tyres (Hird *et al.*, 2002).

The same calculations are not deemed necessary for energy sourced from the national grid as part of the production stage of the mass balance. This would have accounted for mass flows in the energy sector, rather than directly from the motor industry and therefore would have involved double counting.

A4.4 Calculation of waste arising

Chapter 7 presents estimates of waste arising from the manufacturing and use stages of the mass balance. This section presents a discussion on the methodology adopted for evaluating of the quantities of solid, liquid and sludge waste arising at each stage.

A4.4.1 Manufacturing waste

In 1998 the Environment Agency conducted the Strategic Waste Management Assessment (SWMA) survey (EA, 2000b) on various categories of waste generated in England and Wales. Data on industrial and commercial waste was also collected from a statistical sample of businesses of various sizes in each region. While the published SWMA reported information per major economic sector (following the SIC), the more detailed data were used to set up a number of web-based tools detailing arisings for each type of business.

The first tool of interest is the Waste Benchmarking tool (EA, 2003). For every SIC code (down to three digits), the tool gives a detailed description (quantities and quality) of the average waste material produced per company or per employee, for each business part of one of the four size bands i.e:

- Less than 10 employees.
- 11 to 24 employees.
- 25 to 249 employees.
- More than 250 employees.

An overall average was also available. The users (mainly businesses) can therefore compare their waste production to the relevant average for England and Wales.

The tool was used to gather information about the waste produced by the SIC codes of interest for the motor industry production stage (see Table A4.5 for SIC codes and percentages used). An example of the output data is presented in Table A4.8. The detailed information of the status of each waste material (liquid, solid, sludge; special or not) was used to estimate the relevant arisings.

The overall production of waste from the whole of the industry was calculated using the available statistics on active businesses, published in the ONS publication PA1003 (ONS, 2001b), which reports number and location of businesses for each SIC code (down to 4 digits) grouped by employee size bands.

The PA1003 is produced from the Inter Departmental Business Register (IDBR), which provides the basis for the ONS to conduct surveys of businesses. The main administrative sources for the IDBR are HM Customs and Excise, for VAT information and Inland Revenue for PAYE information. The IDBR combines the information on VAT traders and PAYE employers with ONS survey data in a statistical register comprising two million enterprises from the whole of the UK. These two comprehensive administrative sources combined with

Table A4.8 Waste arising for SIC code 32.1 (all business)

Waste type	*S*	*Form*	*Average weight*		*The range is included to indicate variability in waste production between companies: see glossary for explanation*
			/employee	*/company*	
Oil sludges and/or oil water mixtures	Y	Liquid	2.4845	5726.16	120.14 - 8713.89
Iron	N	Solid	1.2781	4408.29	n/a
Mixed ferrous metal	N	Solid	1.3954	4203.92	n/a
Steel	N	Solid	0.9981	3297.56	63.86 - 4001.18
Mixed ferrous and non-ferrous metal	N	Solid	1.3571	3206.72	55.71 - 4342.37
Coated or chemically treated timber	N	Solid	0.7125	- 1861.54	114.44 - 4199.53
Industrial waste	N	Solid	0.5882	1073.59	128.79 - 2049.74
Wood	N	Solid	0.2493	737.92 ‘	63.33 - 146556
Paper and/or card	N	Solid	0.1227	442.18	3457 - 567.7
Aluminium	N	Solid	0.2513	434.62	46.73 - 753.74
Aliphatic hydrocarbon	Y	Liquid	0.1592	422.93	n/a
Aqueous paint		Sludge	0.0653	371.63	n/a
Solvent- or oil- based paint	©	Sludge	0.1142	227.67	n/a
Mixed/unidentified oil	©	Liquid	0.1224	192.11	10.22 - 406.13
General industrial waste n/o/s	N	Solid	0.0735	151.02	9.98-245.1
Other inorganic compounds	Y	Liquid	0.0363	130.46	n/a
Not cleanable contaminated containers, and other packaging	N	Solid	0.0224	128.07	n/a
Other organic chemical wastes	Y	Liquid	0.0213	110.07	n/a
Solvent- or oil- based paint	Y	Liquid	0.0599	96.6	1152 - 201.12
Lubricating and/or fuel oil	Y	Liquid	0.0473	77.16	n/a
Plastics and polymers	N	Solid	0.0094	68.52	7.21-53.88
Undrained lead-acid batteries	Y	Solid	0.0418	54.9	4.72 -124.81
Glass	N	Solid	0.06	54.2	n/a
Waste food - animal or mixed	N	Solid	0.0326	52.31	n/a
Leather	N	Solid	0.0423	43.47	n/a
Sawdust, shavings and/or wood pulp	N	Solid	0.0268	38.19	n/a
Paint, varnish and/or lacquers	Y	Liquid	0.0164	37.75	n/a
Not cleanable contaminated containers, and other packaging	Y	Solid	0.0151	31.2	n/a
Tyres	N	Solid	0.0147	23.56	n/a
Cleanable contaminated containers, and other packaging	Y	Solid	0.0107	20.53	n/a
Light bulbs	N	Solid	0.0079	19.25	1.1-43.28
Contaminated vegetable and/oranimal matter	Y	Solid	0.0072	18.18	n/a
Vehicles and/or metal vehicle parts	N	Solid	0.0041	14.97	n/a
Organophosphorus compounds	Y		0.0085	11.79	n/a
	N	Solid	0.0036	8.92	n/a
Dressings	N	Solid	0.0064	8.01	n/a
Solvent- or oil- based ,paint	Y	Solid	0.0104	7.57	n/a
Vegetable oils, fats, waxes and/orease	N	Liquid	0.0021	4.53	n/a
Other halo enated compounds	Y		0.0018	4.48	n/a
Cable and/or wire	N	Solid	0.0038	4.09	n/a
Sanitary wastes	N		0.0021	3.83	0.51-8.56
Healthcare risk wastes	N	Solid	0.0003	0.48	n/a
Infectious waste	N	Solid	0.0002	0.22	n/a
Sharps	N	Solid	0	0.04	n/a

Source: Environment Agency, 2003.

ONS survey data contribute to the coverage on the IDBR, which represents nearly 99% of UK economic activity. The edition used (ONS, 2001b) reports data on businesses existent in the current year (data relate to April 2001). Data on local active units and enterprises are subdivided into SIC codes (down to four digits) and at national level for each code, by size (by turnover and employees size bands).

The PA1003 classifies the businesses using different size bands with respect to the Environment Agency, and therefore summing up or further subdivisions of the bands was necessary, as detailed in the Table A4.9.

The combination of the two sets of information (the Waste benchmark tool with the PA1003) was performed by:

- Matching the grouping of business in the PA1003 to the grouping in the Waste Benchmarking tool.
- Multiplying the waste arising for each SIC code and size band for the number of relevant businesses in the whole and/or part of the UK (England and Wales, Scotland, Northern Ireland), maintaining the details of the status of the waste (liquid, solid, sludge).
- For each SIC code, applying the relevant contribution (percentages shown in A4.5) to obtain an estimate of the waste generated manufacturing of goods for the motor industry.

For SIC code 34 (100% contribution to the motor industry), estimates of special waste production were obtained by maintaining the details given in the Waste Benchmarking tool, while details on the disposal options adopted by the same code were obtained by using the Waste Exchange/Material Calculator (EA, 2003). This second web-tool set up by the Agency with the data collected during the SWMA survey allows an estimate of the quantities of some relevant recyclable materials (metals, wood, glass, paper and cardboard) disposed of (or already recycled) by businesses (once again grouped by SIC code) in each region.

The methodology adopted for calculating the waste arising at the production stage has some limitations. The Waste Benchmarking Tool has been built using information collected for the 2000 SWMA for England and Wales only, which reports data for the year 1998. Two major assumptions have therefore been made when calculating the arising in the whole of the UK for the year 2000:

1 Production of waste for 2000 were assumed to be the same as 1998 levels, as the SWMA is the most up to date source of information.

2 Businesses active in NI and Scotland produce the same amount of waste as their English and Welsh counterparts.

A4.4.2 Vehicle use and maintenance

The mass of components replaced on UK vehicles was examined because some of the existing PRODCOM data did not account for second hand parts, disclosed data and parts in stock.

The weights of the components were based on estimates from local garages. The garages were asked to estimate the weight of each component. The lifespan of the components in miles was established through personal communication with trade associations and a literature search. The total mass of parts replaced through maintenance per annum was calculated therefore as follows:

$$\left(\begin{array}{l}\text{Average number of miles}\\ \text{per vehicle per annum}\end{array} \Big/ \begin{array}{l}\text{Average component}\\ \text{lifespan in miles}\end{array}\right) \times$$

$$\begin{array}{l}\text{Component}\\ \text{weight}\end{array} \times \begin{array}{l}\text{Number of components}\\ \text{fitted to each vehicle}\end{array} \times \begin{array}{l}\text{Number of vehicles}\\ \text{in use}\end{array}$$

where

$$\begin{array}{l}\text{Average number}\\ \text{of miles per vehicle}\\ \text{per annum}\end{array} = \begin{array}{l}\text{Total number of}\\ \text{miles travelled}\end{array} \Big/ \begin{array}{l}\text{Number of}\\ \text{vehicles in use}\end{array}$$

These data were obtained from DfT transport statistics.

These figures are likely to underestimate the mass of components arising, because they do not include parts used for vehicle modification.

Since it has been assumed that the mass of parts used during maintenance was the same as the mass of parts

Table A4.9 Table to compare PA1003 and Environment Agency size bands

PA1003 bands	A=0 - 4	B=5 - 9	C=10 - 19	D=20 - 49	E=50 - 99	F=100 - 249	G=250 +
EA bands	H=up to10		I=11-24	J=25-249			K=250+
	H= A+B +1/10 * C		I= 9/10*C +5/30 * D	J=(6/30*D)+E+F			K=G

arising, these figures are included in the mass balance as waste arising during maintenance. The new replacement components produced and used in 2000 for these activities are already included in the import, production and export figures, and are therefore not included as a separate additional mass in the calculation.

Parts removed also include used tyres. According to Hird *et al.* (2002), it is possible to calculate tyre wear and rubber lost for different vehicle types, based on number of tyres replaced per vehicle type per annum. This study used the same approach, but needed to approximate as broadly similar the behaviour of:

- Car, LGV and motorbike tyres.
- HGV and bus or coach tyres.

Factors were calculated for tyre wear by subtracting the used mass of tyres from new mass. The mass of tyre wear was then calculated from the product of the number of vehicles in 2000, the fraction of tyre life used on average per year, number of tyres per vehicle and mass of rubber lost by each tyre during wear.

In the case of fluids, the fluids supplied for use in maintenance needs to account for the fact that fluids are lost during maintenance activities. In the case of waste oil arisings, an DETR report (2001b) has estimated that only 55% of total waste oil available is collected, implying that 45% is lost during use. It has been assumed that this applies to all waste fluid arisings. The total mass of fluids used in maintenance is given by the sum of the mass of fluids lost and mass of fluids arising as waste from maintenance.

A4.5 Number and mass of ELV arisings for 2000

A4.5.1 Number

Published data on the number of ELV arisings were of limited use to this particular study because they only cover ELVs as defined by the ELV Directive i.e. passenger cars and light goods vehicles (e.g. Kollamthodi *et al.,* 2003a). Therefore, this study needed to provide a repeatable, transparent method of calculating statutory ELV arisings and non-statutory ELV arisings (HGVs, buses/ coaches and motorcycles).

A4.5.2 Sources of ELVs

A vehicle can reach the end of its life in two main ways. The first occurs when a vehicle of any age is terminally damaged as a result of an accident, flood, fire or theft. Such vehicles are termed ‘premature ELVs’ due to the fact that their useful life has been curtailed as a consequence of terminal damage. The second is when a vehicle comes naturally to the end of its life (termed natural ELVs).

Premature statutory ELVs

The age of a premature ELV will vary depending on the age distribution of the vehicle parc (Ambrose, 2001). It has been assumed that premature ELVs, by their nature, are representative of the broad spectrum of vehicles in the vehicle parc, and that their average age will be the same as the average age of the vehicle parc, i.e. 6.7 years.

In determining whether a vehicle should become a premature ELV (rather than being repaired and returned to the vehicle stock), vehicles are placed into four categories by insurance company motor engineers, depending on the amount of damage sustained. Full details are given in the Code of Practice for the Disposal of Motor Vehicle Salvage, as revised by the Motor Conference[2] in March 2000 (Motor Conference, 2000).

- Category A vehicles – the vehicle has no economically salvageable parts and can be used only as scrap (e.g. ‘total burn outs’).
- Category B vehicles – the vehicle cannot (or should not) be repaired but still has parts which are economically viable for resale (heavy damage such as bent chassis).
- Category C vehicles – the vehicle can be repaired, but the repair costs exceed the pre-accident value of the vehicle (insurance write-offs).
- Category D vehicles – the vehicle can be repaired, and repair costs do not exceed the pre-accident value of the vehicle, but a decision has been made not to repair.

Some designated write-offs (primarily Categories C and D) will be sold for repair and reuse.

Natural statutory ELVs

Natural ELVs are vehicles that have come to the end of their life through ‘normal’ wear and tear. They arise either directly from private vehicle owners/garages, or indirectly from local authorities, if vehicles have been abandoned. Until 1998, these vehicles had a commercial scrap value but as a result of the low price of steel (world-wide) and increasing costs of depollution/disposal, dismantlers are now often charging owners/garagel and local authorities to process natural ELVs. This has a led

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[2] *Motor Conference is the Standing Joint Committee of the Association of British Insurers and Lloyd’s Motor Underwriters’ Association.*

to an increase in the number of vehicles abandoned by private owners.

Some of the vehicles reported abandoned are either returned to their owners, or administered by insurance companies as premature ELVs.

The number of abandoned vehicles arising was based on a survey of local authorities for a report on statutory ELVs (Kollamthodi *et al.*, 2003).

Variation within the statutory ELV stream

It is extremely difficult to characterise the ELV stream for cars and LGVs due to the large number of different vehicle types present in the vehicle parc in any given year. Different vehicles will vary in terms of weight and material composition, even within between model types, which are constantly changing.

SMMT compile data on the best selling cars using editions of 'Autocar' magazine and 'What Car?' magazine published between 1984 and 2000. Where available, lists of the top twenty selling vehicles and the number of sales of each model were obtained. For certain years, only data regarding the top ten selling passenger cars was available. Data on the best selling light goods vehicles were obtained directly from SMMT, and in this case data was only available to cover the years between 1990 and 2000. By knowing what the best selling vehicles were for a given year, along with the average age of a premature ELV and the average age of a natural ELV, it is possible to model the composition of the ELV streams in terms of the specific vehicle models (e.g. Ford Escort) that will appear most abundantly in any particular stream. This method has been used to identify the arisings of car and LGV ELV arisings.

Heavy goods vehicles, buses and coaches and motorcycle arisings

Data are widely available for the determination of ELV arisings for cars and LGVs. It was important to determine statutory ELVs most accurately because they make up the majority of the vehicle parc. However, the inclusion of other vehicle categories within the definition of the UK motor industry has required the identification of further information sources and analytical techniques to estimate non-statutory ELV arisings in a robust manner.

For HGVs, a personal communication from HGV dismantler indicated that the change in vehicle weight in the past decade has been negligible. Therefore, the average weight calculated for an HGV in each class in 2000 has been used to calculate the mass of HGV ELVs. This assumption has also been applied to buses and motorcycles.

A4.5.3 Statutory and non-statutory ELV arisings

The number of vehicles becoming ELVs each year could theoretically be obtained from the Vehicle Information Database (VID). This database is managed by the Department for Transport, (DfT), with information collated from the Driver Vehicle Licensing Agency (DVLA) and Driver and Vehicle Licensing Northern Ireland (DVLNI) administration data. Although both registration and de-registration processes are administered by DVLA, de-registration data (resulting from exports and vehicles reaching end of life) are not currently accessible on the VID. In addition, as last owners do not always formally de-register their vehicles with DVLA, the accuracy of the de-registration data currently housed is questioned. An estimate of the number of ELVs arising was therefore made using the model described below.

The model has been devised to determine ELV arisings in 2000 and estimate the mass this equates to. Estimates have also been made to split this figure by the nine planning regions, Wales, Scotland and Northern Ireland. Using this methodology and assumptions based on historic trends, predictions of future ELV arisings have been made.

The number of ELVs arising in 2000 can be calculated from:

$$(A+B)-(C+D)$$

Where: A = Vehicle stock at the end of 1999
B = New registrations in 2000
C = Vehicle stock at the end of 2000
D = Exports

Main assumptions

To facilitate the calculations a number of assumptions have been made. These are listed below.

1. In 2000, 3.9% of vehicles in use in England, Wales and Scotland were unlicensed and 10% of those in Northern Ireland (roadside surveys, 1999, DVLA and DVLNI).

2. In 2000, 76% of the vehicles stolen in England and Wales were recovered (Home Office estimate) and 74% and 82% were recovered in Scotland and Northern Ireland respectively.

3. Of vehicles that were reported stolen and remained unrecovered[3]

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[3] *The Stationery Office Limited (2001). Explanatory Notes to the Vehicles (Crime) Act 2001. The Stationery Office: London.*

- 25% were stolen for ringing (given a new identity and put back onto the road unlicensed).
- 40% were stolen and broken for parts.
- 20% were insurance frauds.
- 15% were stolen and then exported.

4 0% of vehicles that were stolen for ringing remained in use (i.e. on the road).

5 0% of vehicles that were stolen and broken for parts remained in use.

6 10% of vehicles that were stolen as insurance frauds remained in use.

7 The proportion of vehicles on the road that were exported, stolen and unrecovered or unlicensed in 2000 is the same across each region.

8 The number of natural ELV arisings in 2000 can be calculated from:

- Total ELV arisings.
- Abandoned ELV arisings.
- Premature ELV arisings.

9 The split of premature ELV arisings between the regions is the same as the distribution of vehicle stock in 2000.

10 The best selling models are representative of the models present in the ELV arisings.

11 The proportion of different types of vehicles in the ELV stream will be the same as in the vehicle stock.

Premature/natural ELVs

Due to the differences in dismantling practices and average weights of natural and premature ELVs, it is necessary to determine what proportion of the ELV stream each comprised. The number of natural ELVs that are not abandoned are calculated as the difference between the total ELV arisings and the number of premature/abandoned ELV arisings. The number of abandoned vehicles collected and disposed of ly local authorities was estimated based on data obtained directly from the relevant local authority.

Generic UK data on premature vehicle arisings were obtained from the Association of British Insurers, and industry sources used to estimate the proportion that become ELVs and those that are resold for repair and use. This equates to between 80% and 90% of both category C and D vehicles becoming ELVs (Overton Garage, personal communication, 2002; Universal Salvage personal communication, 2002). It is not currently possible, however, to determine exactly what happens to a vehicle once it is sold by a salvage operator.

It is difficult to identify from which local authority area premature ELVs are arising. However, if it is assumed that the proportion of premature ELVs arising (in relation to vehicle stock) in any local authority area is the same, an estimate of the geographical location can be made. It should be noted, however, that vehicle theft rates and hence numbers of premature ELVs arising will vary with location.

Average age

Due to the trend of increasing car weights over the last few years, the average age of a car or LGV ELV is also necessary to convert the number of ELV arisings to mass. The average ages of ELV arisings can be obtained from the age distribution of those vehicles de-registered in 2000. Using this information, the average age of a de-registered vehicle was calculated as being 12.1 years. Although de-registration data consists, for the most part, of natural ELVs, it should be noted that the data also includes premature ELVs, and vehicles that have been exported. Correcting this data to remove the influence of premature ELVs gives an average age for a natural ELV of 12.8 years (calculated using DTLR Vehicle licensing statistics 2000).

For HGVs, buses and motorcycles, it has been assumed that there is no change in weight over time, therefore no age calculations were required.

A4.5.4 Mass of ELV arisings

Two methods have been developed for estimating the weight of ELV arisings.

Method 1: Historical sales analysis for statutory ELVs

This takes into account the differing weights of different model types and that this will change from year to year. It uses historical data on the best selling makes and models in order to estimate the weight of ELV arisings.

In light of the lack of information regarding sales of vehicle models not included in the top ten or top twenty best sellers, it was necessary to assume (for the purposes of the prediction model) that the best selling models were representative of all ELV arisings. This is a valid assumption to make as the twenty best selling passenger car models typically account for between 65% and 70% of all car sales and others will be similar in type and therefore in weight. For years where data for only the ten best selling models was available, the sampling is obviously less representative; the ten best selling vehicles typically account for between 40% and 55% of all new car sales.

The sales of each model were then determined as a percentage of the top 20 / top 10 total sales. The resultant percentage weightings approximately reflect the proportions in which each model of car or goods vehicle arises in the ELV stream. It has been assumed that car and light goods vehicle ELVs will arise in the same proportions as they do in the vehicle stock (91% cars and 9% light goods vehicles). As discussed earlier in this section, estimates have already been made with regard to the number of premature and natural ELVs arising in 2000. Using the known kerb weights for these models, the average weight of each type of ELV in 2000 can be estimated. Thus, the mass of Statutory ELV arisings (vehicles leaving the parc that are not stolen and unrecovered) is given by:

(Number of premature car ELVs
× mass of premature car ELV) +

(Number of natural car ELVs
× mass of natural car ELV) +

(Number of premature LGV ELVs
× mass of premature LGV ELV)

(Number of natural LGV ELVs
× mass of natural LGV ELV)

Method 2: Using an average mass of vehicle for class for non-statutory arisings

For HGVs, buses and motorcycles, the mass of ELVs arising has been based on determining the mass of a typical ELV for each class and multiplying this figure against the total ELV arisings. This has been based on the following assumptions:

1 There is no change in the mass of ELVs over the last decade.

2 Following from 1 above, there is no significant difference between premature and natural ELVs arising in terms of weight.

Thus, the mass of non-statutory ELV arisings in 2000 (vehicles leaving the parc that are not stolen and unrecovered) is given by:

Number of ELV arisings per class
× Average mass for that class of vehicle in 2000

HGV, bus and motorcycle classes and corresponding weights are assumed the same as for the product calculations (see Table A4.2).