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ENVIRONMENTAL DATA FOR GERMANY

Practicing Sustainability – Protecting Natural Resources and the Environment

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For Humanity and Environment

DEVELOPMENT OF THE CONSUMPTION OF NATURAL RESOURCES – SELECTED PARAMETERS

Themes	Year/ Period	Quantity/ Change
RAW MATERIALS		
Domestically extracted raw materials		
Total	2005	650 mi. t
Building sand and gravel	2005	260 mi. t
Building sand and gravel	1995–2005	−36 %
Rock and industrial salts	1995–2005	+34 %
Imports of unrefined metals		
Imports as a proportion of total requirements	since 1988	100 %
Development of the prices of selected raw materials		
Nickel	2002–2006	+350 %
Copper	2002–2006	+400 %
Total consumption of selected unrefined metals		
Aluminium	1995–2003	+38.4 %
Lead	1995–2003	+1.4 %
Copper	1995–2003	+12.4 %
Total consumption of selected industrial minerals		
Fluorite	1995–2003	+17 %
Phosphates	1995–2003	−65.6 %
Potash fertilizer	1995–2003	−49.6 %
Magnesite	1995–2003	−13.6 %
Recycling of selected metals referring to total consumption		
Lead	1994–2003	+23.5 percent-age points
Copper	1994–2003	+12 percent-age points
Total consumption of raw materials (incl. imports)	2004	1 337 mi. t
Waste generation		
Total	2002–2004	−11 %
Waste recovery quota	2004	65 %
ENERGY		
Primary energy production	1990–2005	−39 %
Hard coal production	1995–2005	−53 %
Lignite production	1995–2005	−8 %
Net imports of primary energy	1990–2004	26.8 %

DEVELOPMENT OF THE CONSUMPTION OF NATURAL RESOURCES – SELECTED PARAMETERS

Themes	Year/ Period	Quantity/ Change
ENERGY		
Gross domestic consumption	1990–2005	−4.7 %
Renewable energy: contribution to primary energy consumption	1998–2005	+2.4 percentage points
Renewable energy: contribution to final energy consumption	1998–2005	+3.3 percentage points
Gross electricity generation, total	1990–2005	+12.6 %
Total energy used to generate electricity	1990–2005	−1.1 %
Renewable energy's share of electricity consumption	2005	10.2 %
Fuel consumed by road traffic		
Total consumption	1991–2005	+6 %
Passenger transport	1991–2005	−2.9 %
Road freight transport	1991–2005	+38.2 %
Primary energy consumption – private households	1995–2004	+0.9 %
Energy-related emissions of greenhouse gases	1990–2004	−147.8 mi. t CO_2 equivalents
LAND AREA		
Settlement and transport areas	2002–2005	+114 ha/day
Settlement areas of production sectors	1996–2004	+6.4 %
Area used by private households		
Settlement area	1996–2004	+15.9 %
Residential area (actual area used)	1995–2004	+13.1 %
WATER		
Total water extraction	2004	35.6 bi. m^3
Water supplied to end users	1991–2004	−17.7 %
Water consumption by production sectors	1995–2004	−18.8 %

Preface

The world's economy is directly dependent on the use of natural resources. The extent to which resources are being used is reducing our planet's capability to regenerate the fundamentals required in order to sustain human and animal life. Consequently there is a basic need to replace the current patterns of resource usage by a sustainable economic system. On a local level urgent action must be taken in accordance with long term, just principles, and this is also evident from the rapid pace with which resources are being consumed to meet the vigorously expanding economies of the emerging markets. If the customary patterns of consumption were to be retained, the worldwide rate at which resources are being used up would multiply several times over during the next 20 years, far exceeding the natural capacity for regeneration, to the detriment of the basis of life for current and future generations. It is therefore vitally necessary that all countries make the change to a sustainable economic system, with more efficient use of resources, abandoning the intensive use of these resources and adopting lifestyles that help to protect them.

Germany is one of the countries that have declared their commitment to Agenda 21, the campaign for environmental action in the 21st century that has been proposed by the United Nations Conference on the Environment and Development (UNCED, 1992). Agenda 21 seeks to combat worldwide ecological, economic and social deterioration, to improve the situation in a number of stages, and ensure the sustainable use of natural resources. In the debate about intra- and inter-generational justice according to the World Commission in Environment and Development (WCED, 1987), sustainable management means being able to satisfy the needs of the current population, taking into consideration the ability of the earth to cope with the stresses to which it is exposed, by adopting appropriate economic, environmental and development policies, but without jeopardizing the basis of life for future generations and their need to satisfy their own requirements.

This brochure offers a review, supported by relevant data, of the provision and use of the economically significant resources needed for production, and of their consumption by private households in Germany. The categories of resources dealt with by this study are confined to raw materials, energy, water and land area, and it shows the immediate environmental impact resulting from their use, together with social measures intended to reduce the pressures on the environment. The indicators and trends show the point at which gains in efficiency become apparent in the patterns of provision, production and consumption. Figures and trends also clearly show where specific improvements are necessary to ensure the efficient use of resources. These figures and trends are a quantified basis, serving as guidelines which Germany can use to formulate instruments and measures to attain the common objective of decoupling the pressures on the environment from economic developments and of reducing environmental pollution in accordance with the *thematic EU-strategy for the sustainable use of natural resources.*

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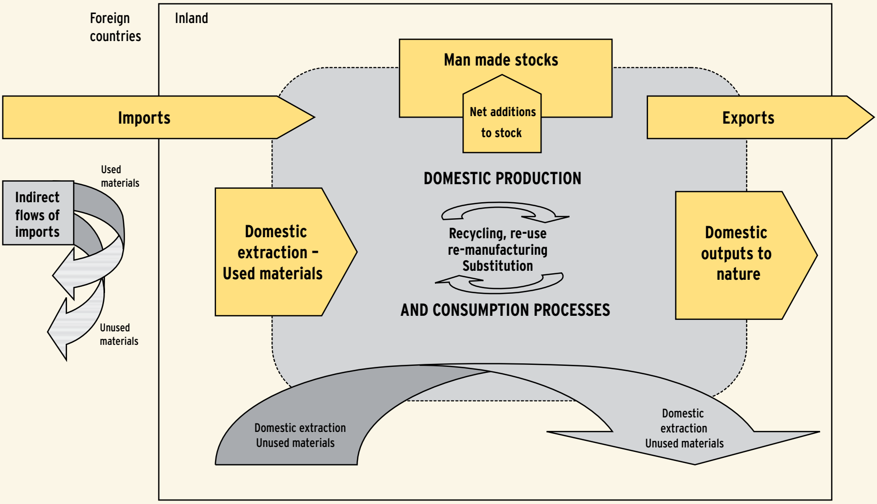
DEVELOPMENTS IN NATURAL RESOURCE USE

Economy-wide material balance scheme



Source: *OECD 2007 (1a)*

Our daily requirements cannot be met without natural resources, in the form of raw materials, energy, water and land area, and neither can there be any foundation for prosperity without them. As a highly developed industrialized nation with a very high population density Germany is particularly dependent on these resources. Consequently the principles of sustainable management as defined by Agenda 21 impose particular demands on the provision and use of these resources for various purposes in meeting everyday needs. This chapter provides a summary and offers a selection of comprehensive parameters for the provision and use of these resources, which will be explained in greater detail in subsequent chapters.

Raw materials

Extraction, import and exploitation of raw materials

Mass raw materials such as sand and gravel used in construction, natural rock and lignite (for energy supply) are extracted in Germany and largely meet domestic requirements. In 2005 the amount of mineral raw materials extracted totalled some 650 million t, which included 260 mi. t of sand and gravel and 270 mi. t of natural rock. Over the past 10 years there has been a sharp decline in the extraction of the following mass raw materials in Germany: sand and gravel for construction (approx. −36 %), coal (approx. −53 %), lignite (approx. −8 %), quartz sand (approx. −20 %). During the same period the extraction of quantitatively less important raw materials increased significantly, for example rock and industrial salts (+34 %), flue gas desulphurized gypsum (+100 %), potassium salt (+12 %). In 2005 alone Germany extracted 19.3 mi. t of salts and is the leading salt producer in the European Union.

On average, for each tonne of domestically extracted raw materials a further 2.2 t of raw materials and ancillary matter is produced which cannot be exploited as so-called indirect flows of materials and, in the case of lignite mining, this amounts to an additional 8 t for each tonne exploited. Indirect flows of materials also occur in other countries but the quantities involved cannot be ascertained due to a lack of reliable data.

Germany is highly dependent on imports of metals, since these raw materials are not available domestically in any significant quantities. Approximately 100 % of the country's requirements for metals have to be met by imports. Within the EU Germany is the largest consumer of metallic raw materials. Over the past 15 years imports of the raw materials of metals as well as of precious metals and stones have remained more or less constant. In contrast the total consumption of certain metals such as aluminium and copper have risen, reflecting the growing proportion that is being recycled (see also Recycling Industry).

In 2004 Germany consumed 1 337 mi. t of abiotic raw materials (including imports) – 1 253 mi. t of this alone being supplied in advance prior to production and for consumption by private households, and a further 84 mi. t for export. In addition, Germany deployed 261 mi. t of biotic raw materials from its own production and from imports, which amounted to 15.4 % of all the materials used by the economy as a whole.

Closed substance cycle management

The basic principles of the closed substance cycle and waste management act are concerned with the creation of closed material cycles. Firstly every effort must be made to avoid the production of waste. Secondly any unavoidable waste must be correctly and harmlessly reprocessed. Waste, which cannot be reprocessed, must be disposed of in an environmentally safe way.

There are hardly any natural deposits of metals in Germany. Metallic raw materials are in ever-shorter supply and, combined with rising prices for metals, this has led Germany to become one of the leading countries for the reprocessing of metals. For example more than 50 % of its steel, lead and copper is obtained from recycling, and more than 40 % of its nickel.

The tendency in Germany in recent years has been for a decline in the overall amount of waste produced, and in 2004 some 65 % was reprocessed. Construction and demolition waste are significant in quantitative terms, with 86 % currently being reprocessed, followed by waste from settlements and waste from manufacturing industries, 57 % of which is reprocessed in each case, while 68 % of waste materials requiring special monitoring are being reprocessed.

Raw material and waste intensity

The above trends, combined with an increase in economic output, have resulted in a decline in raw material intensity from 819 kg/thou. EUR in 1994 to 613 kg/thou. EUR by 2005, while waste intensity fell between 1996 and 2004 from 204 to 161 kg/thou. EUR.

Energy

Domestic production and imports

Domestic production of primary energy has fallen by nearly 40 % over the past 15 years, from 6 224 PJ to 3 802 PJ. Of all domestically produced primary energy, in 2005 lignite accounted for the largest proportion, 42 % (compared with 51 % in 1990), followed by coal, with a 20 % share. During the last 15 years Germany has reduced the amount of coal mined by up to 64 % in favour of less carbon-rich energy carriers, resulting in a substantial decline in emissions affecting the climate. Imports have compensated for the reduction in domestic extraction: net imports rose from 56.8 % in 1990 to 74.4 % of primary energy consumption in 2004. As a result the supply of energy from domestic sources currently only contributes to a quarter of the consumption of primary energy. Germany imports 100 % of its mineral oil and uranium, 83 % of its natural gas and 61 % of its coal. Current lignite extraction still meets all the country’s needs.

Primary and final energy consumption

Despite the economic growth there has been a slight decline in primary energy consumption which, at approximately 14 236 PJ in 2005 (as per September 2006), was 4.7 % lower than in 1990. Between 1998 and 2005 renewable energy as a proportion of primary energy consumption rose from 2.2 % to 4.6 %.

In 2004 the production sector was responsible for some 66 % of primary energy consumption, compared with around 34 % by private households. Within the production sector manufacturing dominated with a 42 % share.

About two thirds of all primary energy consumption was used in the final energy sectors. Between 1998 and 2005 renewable energy as a proportion of final energy consumption rose from 3.1 % to 6.4 %.

In 1990 industry, with more than 30 %, was still the largest consumer of final energy, but by 2005 it had been replaced by households and transport, each with a share of approximately 29 %.

Today the end energy consumption by transport is 3.6 % points higher than in 1990. In 2005 fuel consumption by road transport was approximately 3.7 bi. litres higher than in 1991, corresponding to a 6 % increase, with different rates of development in the consumption by passenger and freight transport. Between 1991 and 2005 there was a 2.9 % reduction in the consumption by passenger transport, a consequence of higher fuel costs, greater availability of public transport and a reduction in specific fuel consumption as a result of technical improvements in vehicle design. Meanwhile, over the same period, consumption by road freight transport actually rose by 38 % due to a significant increase in the transport of goods by road, more than cancelling out the benefits of any technical measures for reducing consumption.

Energy for generating electricity and heating

Between 1990 and 2005 total gross electricity generation was forced up by some 13 % as a result of increases in demand by industry (+ 21 %) and households (+ 13 %). In contrast the amount of energy used to generate electricity fell by 1.1 %. This reflects the considerably more efficient conversion of energy achieved by new power plants. The average fuel efficiency of power plants rose from 36.5 % to 41 %. Between 1998 and 2005 renewable energy as a proportion of gross energy consumption rose from 4.8 % to 10.2 %: The German government's objective is to achieve a proportion of 12.5 % by 2010, and approx. 20 % by 2020. The contribution made by renewable energy to the provision of heating has risen from 3.5 to 5.3 %.

Greenhouse gas emissions

Between the base year (1990 for almost all greenhouse gases, 1995 for so-called f-gases only) and 2004 the amount of greenhouse gases released into the atmosphere in Germany fell by 217 mi. t of CO_2 equivalents, or 17.6 %. There is therefore still a shortfall of 3.4 % to be made up before the period 2008 to 2012 if the Kyoto objective is to be attained. The energy sector is the main source of emissions and in 2004 it was responsible for 81.5 % of all emissions of greenhouse gases. In this sector emissions declined between 1990 and 1995 by 112.4 mi. t of CO_2 equivalents which, primarily in the new states, was a consequence of economic and technical restructuring to improve energy efficiency, the substitution of carbon-rich fuels by low-carbon forms of energy, and an increase in the contribution made to energy supplies by renewable energy. With the exception of transport, between 1990 and 2004 there was a decline in emissions in all sectors. However, increased use of lignite for electricity generation in recent years, together with the significant rise in overall electricity generation compared with previous years, has again been responsible for greater greenhouse gas emissions in the energy production sector.

According to the General Environmental Account, of the approximate total of 1 174 mi. t of CO_2 emitted in 2003, 58 % was the result of domestic production, private households were responsible for 18 %, and 25 % can be indirectly attributed to import. In quantitative terms export-related CO_2 emissions were some 20 % higher that those linked with imports.

Energy intensity, emission intensity and transport intensity

Whereas in 1990 8.7 MJ of primary energy were required to create one EUR worth of added value, by 2005 this figure had fallen to just 6.6 MJ, reflecting the measures to improve energy efficiency such as modernized power plants and the development of the potential for achieving savings in production and consumption. Over the same period the intensity of CO_2 emissions fell at an even greater rate than the energy intensity, and this can be attributed in particular to a shift in primary energy sources in favour of low-carbon and even carbon-free forms of energy. On the other hand no improved efficiency is evident in the transport sector. In 2004 the transport intensity in the passenger sector was only 98 %, below the base value for 1999. In recent years the freight transport output has risen at an even greater rate than that of the gross national product.

Demands on land area

In 2004 the area occupied by settlements and transport accounted for 12.8 % of the total land area in Germany, which was 0.5 percentage points more than in 2000. Every day between 2002 and 2005 settlements and transport expanded to cover a further 114 ha. Half of the area occupied by settlements and transport is sealed, an area of 2.3 mi. ha or 6.4 % of the total land area of Germany. This daily expansion is due not to population expansion but to the increase in the area being used by each member of the population.

Between 1996 and 2004 the settlement area in use by private households increased by 15.9 %, mainly accounted for by housing and open areas. By 2004 private households occupied 52 % of the entire settlement area, compared with 20 % for the service sector and around 13 % for industry.

Despite the high rate at which previously open areas are being occupied, the amount of derelict land is increasing too: between 1996 and 2000 it expanded by around 10 ha daily in cities and municipalities. The amount of derelict land is equivalent to the area required to meet the demand for settlement expansion over a four year period, which is why the regional availability of derelict land should be considered when earmarking new settlement areas.

Only a very small share of the total land area in Germany (< 0.5 %) is occupied by the extraction of raw materials.

Water

Use by industry and private households accounts for approximately 19 % of the available water resources in Germany. Over the past 15 years there has been a noticeable decrease in the amount of water extracted for all areas of the economy, totalling 35.6 bi. m^3 in 2004. With 22.5 bi. m^3, 12 % of the total, thermal power plants were the biggest single users of water.

The public supply requires some 5.4 bi. m^3, which is only about 2.8 % of the water supply available. In 2004 approximately 2 278 m^3 of useable water per head was available to Germany's population of 82.5 mi. This is equivalent to a potential amount of 6 241 l per head per day.

In 2004 ultimate consumers obtained 4 729 mi. m^3 of water from public supplies. The past 13 years have seen a decline of around 17.7 % in the amount of water supplied.

In 2004 losses amounted to just 6.8 % of all the water produced by the public suppliers, a low level compared with the rest of Europe.

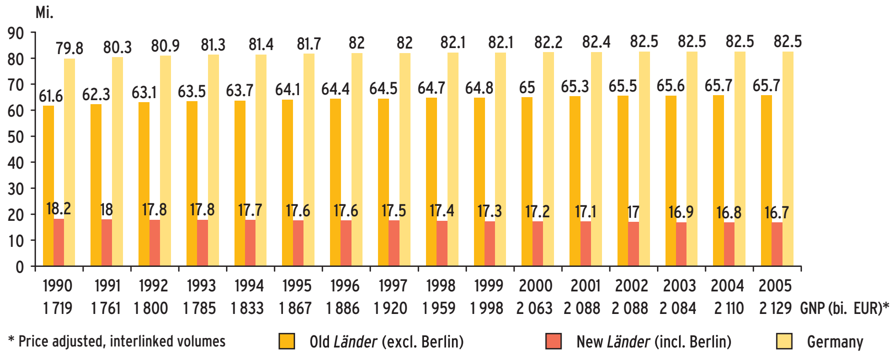
In many production sectors the intensity of water consumption fell significantly. In 2004 water intensity in all areas of production averaged 18 m^3 per thousand EUR value added, while that of manufacturing (excluding the construction industry) was almost 80 m^3/thou. EUR. Over the same period in manufacturing (excluding the construction industry) there was a 28.5 % reduction in water intensity, in particular as a consequence of multiple usage and recycling.

Demand for resources to meet consumption needs of private households

The activities of private households make a significant contribution to the pressures on the environment, the extent of which is determined not only by individual behaviour but also by influencing economic and social parameters such as population increases, the structure of households, and the amount and composition of expenditure on consumption.

As the diagram shows, at the end of 2005 Germany had a population of 82.4 mi., which is only 3.4 % more than at the end of 1990. In comparison, and allowing for price adjustments, gross national product and consumer expenditure have both risen by some 20 % since 1991. In the period under consideration the increasing pressures on environmental resources by private households have thus been exacerbated more by rising prosperity than by increases in the population.

Population development in Germany 1990 to 2005 (31.12.2005)



Source: *Federal Statistical Office 2006*

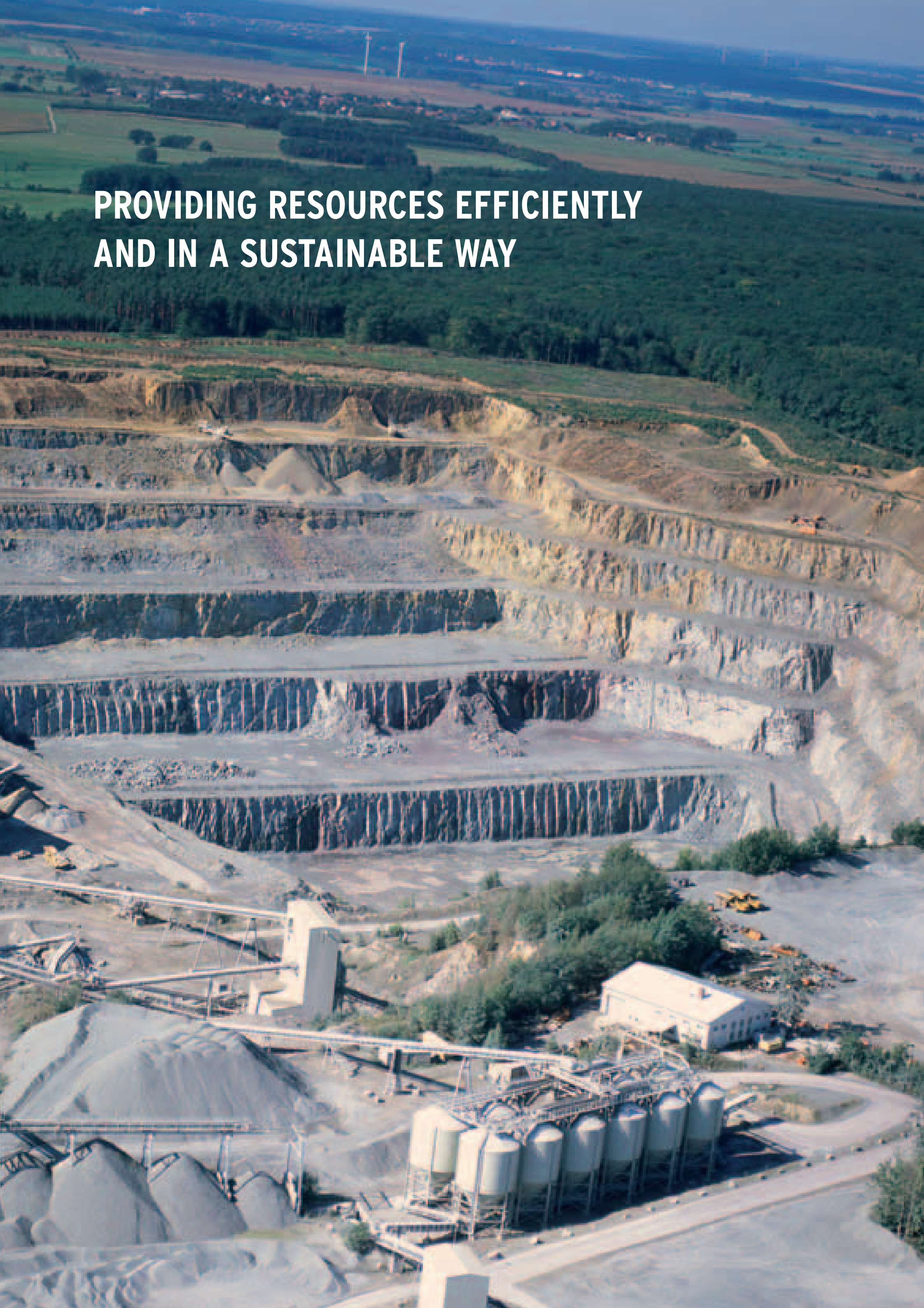
As a result there was a 16 % increase in the demand emanating directly from private households on settlement areas between 1996 and 2004. The area increase per capita has been 15 %. Among the factors contributing to this rise has been the shift from multi-person to one- and two-person households. Over the last decade the number of single and two-person households has risen by some 12 %, contrasting with a 7 % decline in households occupied by two or more persons. At 62.5 m^2 the per capita living area in a single person household is substantially higher than the 43.4 m^2 average for two-person households, or the 28.5 m^2 for those with three or more occupants.

At the present time private households account for 34 % of the total consumption of primary energy, which amounted to some 9 990 PJ in 2003. Of this total 40 % was accounted for by so-called direct energy consumption for housing purposes and for transport fuel, and 60 % by indirect energy consumption for the production of consumer goods. Three quarters of the total energy consumed for housing purposes is used to heat rooms (the main fuels being oil and gas) and a further 11 % is for heating water. This relatively high consumption of energy by ultimate consumers in households can be substantially reduced through the application of modern technology such as more energy-efficient, low-emission heating units burning gas, oil and wood pellets, by heat pumps, solar collectors and energy-saving hot water storage systems. Furthermore, if the housing stock is thoroughly renovated to achieve the best possible energy efficiency, room heating requirements can be reduced by almost 60 %. Germany has at its disposal a number of instruments designed to make the most of this technical potential for reducing consumption.

Between 1991 and 2004 the amount of drinking water consumed in private households and by small-scale traders fell by 9.1 %. Over the same period per capita consumption of drinking water in Germany declined by 12.5 % and now stands at 126 l per head of population per day.

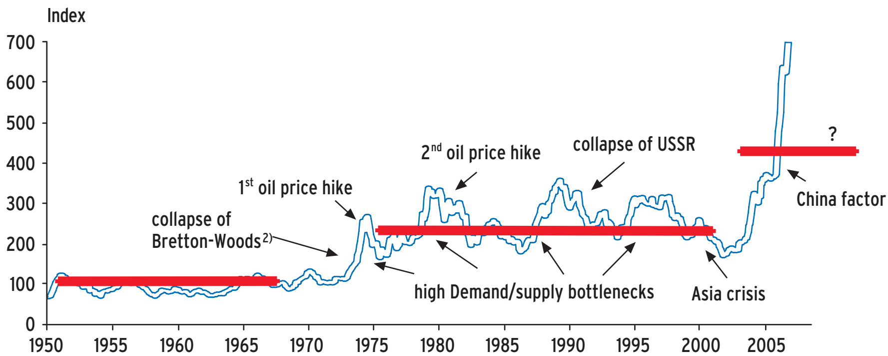
With increasing prosperity an increasing number of households are incorporating technology designed to make the most intensive use of resources. During the past one and a half decades the equipment level for some items installed in homes, for example computers and large appliances, has reached 100 and even 200 %. In addition to the equipment level of such items in households, in mid- to upper income ranges the growing demand in such areas as mobility, leisure/sport, information/ communication and entertainment is contributing significantly to the rate at which resources are being consumed. Against the background of this trend there is a pressing need for a resources policy that encourages the use of sustainable products and sustainable consumption. Product labelling as in the form of the Blue Angel, certification for organic products, Transfair or offer invaluable guidance for anyone considering the purchase of sustainable products.

PROVIDING RESOURCES EFFICIENTLY AND IN A SUSTAINABLE WAY



The current market situation

Development of raw material prices and CRB[1] Metals Sub-Index (basket of goods compr. copper, steel, scrap lead, tin, zinc)



1) Commodity Research Bureau

2) Financial and monetary system, named after the Bretton Woods Conference, which established the US dollar as the dominant currency, backed by gold, until 1973

Source: *Reuters CRB Metals Sub-Index 2006*

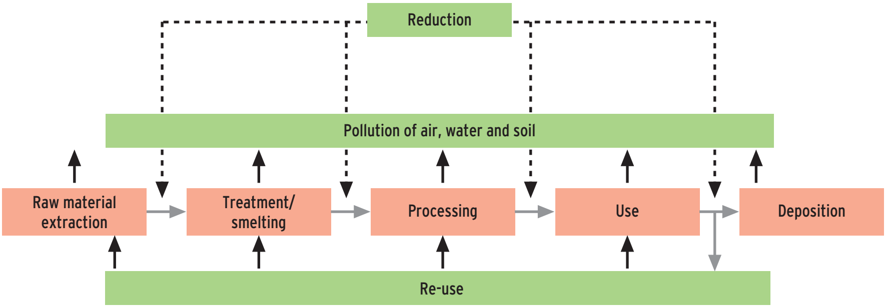
Following a period of reduced demand for raw materials in the 1990s, and as a result of weaker world economic growth, the increase in global industrial production is accompanied by a higher demand for raw materials, most of them of mineral origin. For the first time for many years, since 2002 demand has exceeded the available supplies of raw materials. For example, between July 2002 and July 2006 the prices for nickel and copper rose by 350 % and 400 % respectively. As a result of these price increases political discussions are again focusing on the question of safeguarding raw material supplies for German industry.

The main reason for the upsurge in prices is China's, and other emerging countries' hunger for raw materials, and the problems associated with the inability for supply to keep pace with demand. Prices are also being forced up by the rising costs of searching for and extracting raw materials and higher sea freight charges, together with bottlenecks among industrial suppliers to the mining sector and the increased demands for maintaining higher environmental and social standards in the mining industry and in processing.

The world economy has already witnessed a number of raw material price cycles over the past 60 years. However, since 2002 the beginning of the new cycle has been characterized above all by an unusually sharp rise in the price of all industrial and precious metals. It is possible that what we are seeing is nothing less than a structural change on the raw materials markets. Furthermore demand for raw materials, which are needed in particular in order to develop the infrastructure in ambitious emerging countries, is fuelling concerns about maintaining sustainable systems of raw material extraction and processing. It is for this reason that the raw materials sector is currently engaged in further development of its certification processes.

Principles of sustainable raw material supplies

Flow of materials during the commercial life cycle of raw materials and reduction in input of materials



Source: *OECD Working Group on Environmental Information and Outlooks 2005 (1b)*

Mineral raw materials form a decisive and fundamental component of the industrial value added chain. That is why, even in the long term, we cannot dispense with them.

Not only is the supply of raw materials subject to market-based criteria, but ecological aspects must also be taken into consideration. Mining and the processing of raw materials have to satisfy strict environmental and social requirements in Germany. The Federal Mining Law stipulates that an examination to determine environmental compatibility must be carried out as precondition for the issue of a licence for the relevant mining projects, and that a 'closure operational plan' is provided to safeguard the future of disused mining areas. All too often sustainability standards are not maintained, with the result that the imported raw materials do not necessarily comply with German notions of sustainable operation. Sustainability strategies have been incorporated by the mining industry in numerous new international initiatives such as the *Mining, Minerals and Sustainable Development (MMSD)* project, and have been supplemented by the aspect of good governance, especially for mining operations in developing countries [1]. The project was initiated by the World Business Council for Sustainable Development (WBCSD) and was supported by the Global Mining Initiative (GMI).

So far international initiatives have not resulted in any uniform and generally accepted system of assessment for the maintenance of sustainability standards, particularly in the mining and raw materials sector and in the associated trading chains.

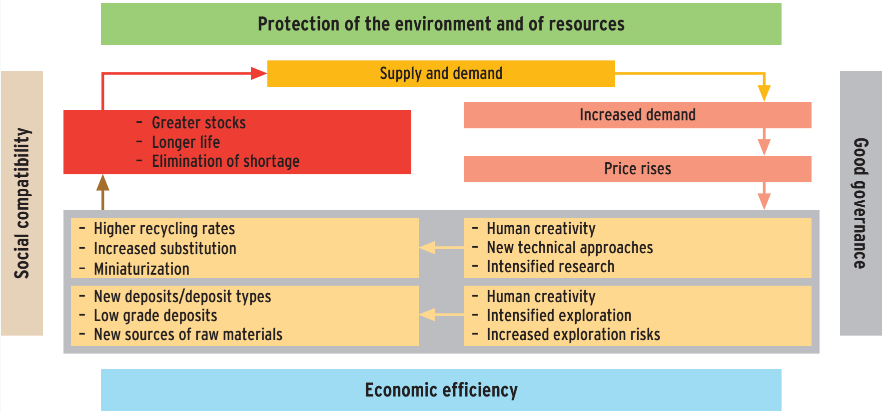
Sustainable operation not only helps to improve environmental and social standards, it also encourages the potential for savings to be exploited. In particular high raw material prices encourage the recycling of raw materials, research into substitutes and new developments in the miniaturization of components, leading to reduced environmental stresses and more intensive use of materials in the case of primary raw materials. High raw material prices should therefore be seen as an opportunity to achieve innovative advances in the sustainable development that promotes economic progress and helps to conserve raw materials.

Market mechanisms

Over a longer period of time mineral raw materials have not become scarcer, nor have they become significantly more expensive in real terms. This is because the availability of raw materials is controlled by means of a regulatory circuit, in which supply follows demand, subject to a certain built-in delay.

The gaps in supply resulting from excess demand cause prices to rise, attracting investors, who provide the finance for exploration work, which is also accompanied by higher risks. Meanwhile supplies are boosted by the development of new mineral projects and new sources of raw materials. A fall in demand, for example during a recession, leads to a supply surplus, causing prices to drop. Human creativity, in the form of improved methods of exploration, savings in materials and the use of cheaper substitutes, can help to overcome a shortage of raw materials, thereby easing the pressure on inflated raw material prices.

Regulatory circuit of raw material supply – The four bases of sustainability

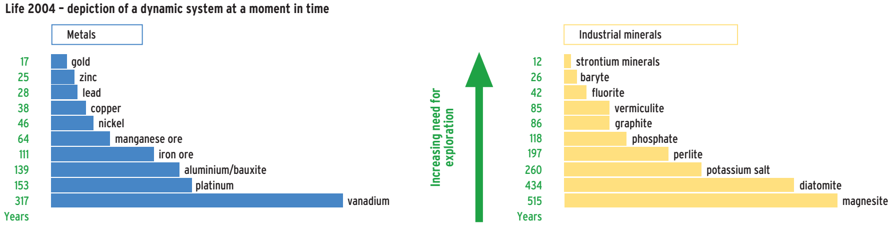


Source: *Federal Institute for Geosciences and Natural Resources 2006*

The time taken for the completion of such a raw materials cycle depends on the economic situation and on the materials themselves and may last several years or even as much as a decade. Many analysts suspect that we are currently in the initial phases of a so-called super-cycle, with considerably longer periods, and due above all to the growing demand for raw materials by emerging and developing countries, and that, in the long term, this will probably result in a lasting increase in the price of raw materials. This means that greater attention will have to be paid to the development of raw material markets and the associated discussions about sustainability.

Lifetime of mineral raw materials

Example of the static range of reserves of metallic and non-metallic raw materials to give an indication of the need for expenditure on exploration

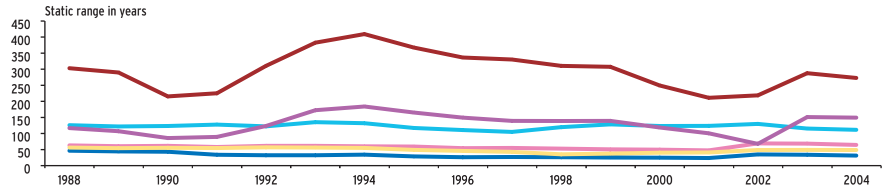


Source: *Federal Institute for Geosciences and Natural Resources 2006 (2)*

A frequently, but incorrectly, used yardstick for assessing the availability of raw materials is their static range or lifetime, indicating the ratio derived from comparing current annual extraction against the existing known reserves (current commercial reserves which can be extracted economically) or resources (reserves plus current uneconomical mineral inventories). The indicator describes the current state of knowledge and therefore provides a picture of a dynamically developing system at a particular moment in time. In reality, however, the output quantities, i.e. the reserves and the production quantities, are constantly changing. The main influencing factors are firstly the progressive exploration and improved working methods. Secondly extraction is adapted to meet the demand for raw materials. Furthermore the price determines both output quantities – the reserves and their extraction.

The indicator for the range or lifetime does not therefore provide any information about the time when all the reserves of mineral raw materials are finally exhausted but is simply regarded by the experts as and indicator of the need for exploration work. This becomes evident if the lifetime development is considered as a time series. In past decades the ranges for most raw materials have remained roughly constant as a long term trend. Exploration and technical progress in the extraction of raw materials were consequently so successful that a dynamic balance between production and reserves could be guaranteed over several decades.

Example of the development of the static range of reserves[1)] and resources[2)] of copper nickel and cobalt over the past 16 years

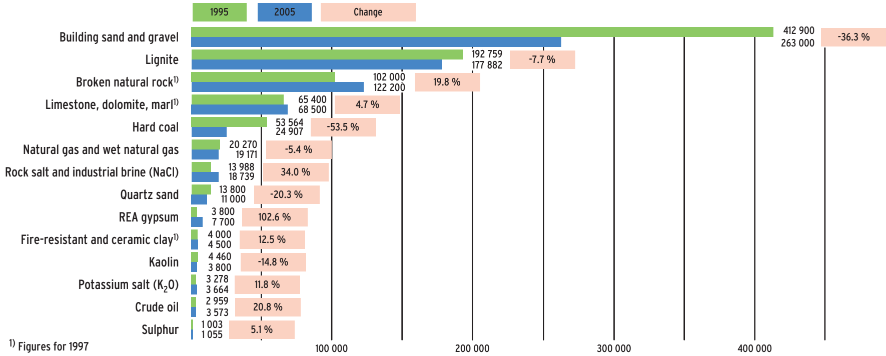


[1)] Stocks whose extraction is currently economically viable
[2)] Reserves plus current uneconomical stocks

Source: *Federal Institute for Geosciences and Natural Resources 2006 (2)*

Domestic extraction of raw materials

Domestic extraction of raw materials 1995 and 2005
(all details in thou. t, natural gas and wet natural gas in mi. m^3)



Source: *Federal Institute for Geosciences and Natural Resources 2006 (3)*

Although raw materials have been extracted in Germany for hundreds of years, the country still possesses extensive and valuable reserves. In quantitative terms 80 % of Germany's requirements for raw materials are obtained domestically. However, Germany depends wholly on imports for the raw materials needed to produce metals. Domestic production of metal ores ceased in 1988[1].

On a world scale Germany maintains its position as an important mining country. It is the world's leading producer of lignite, the fourth largest source of mined kaolin, the third largest for rock salt and fourth for potassium salt. In 2005 some 650 mi. t. of mineral raw materials were extracted.

Sand and gravel are the most important by quantity, accounting for around half of all the mineral raw materials obtained in Germany. Each year just under 2 700 pits supply around 260 mi. t[2]. of these mass raw materials, either by dry extraction methods or by dredging, and almost 95 % is taken away by road. Because of the cost in particular, few possibilities exist for increasing the amounts carried by more ecologically acceptable means of transportation such as railways or waterways. The competition is such that the sale of sand and gravel is only profitable over short distances, and the use of railways and shipping is only profitable where longer distances are involved.

Sand and gravel deposits are distributed throughout Germany, and in particular in the region between the Danube and the Alps, in the Upper Rhine valley, the Lower Rhine basin, North German lowlands and along most of the country's rivers. Germany's reserves amount to several hundred billion tonnes. However, only a fraction of this economically important sand and gravel can be extracted because of conflicts over use (e.g. the use of land by agriculture and the water industry, settlements, na-

[1] In 2004 some 412 000 t iron ore and manganese ore were extracted in Northrhine-Westphalia, but this was used exclusively as aggregate in the construction industry or as highway ballast and chippings.

ture conservation), the interests of other landowners and the increasing cost of the approval process.

Many different kinds of natural rock are used in Germany for civil and structural engineering, and for roads, railways and waterways. They include magmatic rocks (granites, diorites, gabbros, basalts, diabases, porphyrites), metamorphic rocks (quarzites, amphibolites) and sedimentary rocks (limestones and dolomitic rocks, sandstones, greywackes). Volcanic ash and slag as well as pumice are non-compacted mass mineral materials which are used in large quantities by the construction industry as aggregates in the production of concrete. Basalt, one of the best known volcanic hard rocks, is used in many areas of the construction industry.

The National Mineral Raw Materials Federation estimates that some 247 mi. t.[2] of natural rock were extracted in 2005, with a value of 1.4 bi. euros.

In 2005 the German salt industry retained its position as the largest producer of salt in the European Union. Over 3.37 mi. t. from the annual production of some 19.3 mi. t. were exported. Salt extraction from mining and salt works is concentrated in the federal states of Lower Saxony, Saxony-Anhalt, Northrhine-Westphalia, Hesse, Baden-Württemberg, Thuringia and Bavaria.

Germany remains one of the largest producers of mined potassium in the EU. On a worldwide scale Germany ranks fourth, with effective, utilizable production of potassium salts amounting to 6.6 mi. t. (3.6 mi. t. K_2O) in 2005. Raw potassium and magnesium salts are currently being extracted at six mines in Saxony-Anhalt, Hesse, Lower Saxony and Thuringia. These natural raw materials contain vital elements such as potassium, magnesium and sulphur, which are processed to produce high grade mineral fertilisers. A wide range of potassium and magnesium products for industrial applications are also obtained.

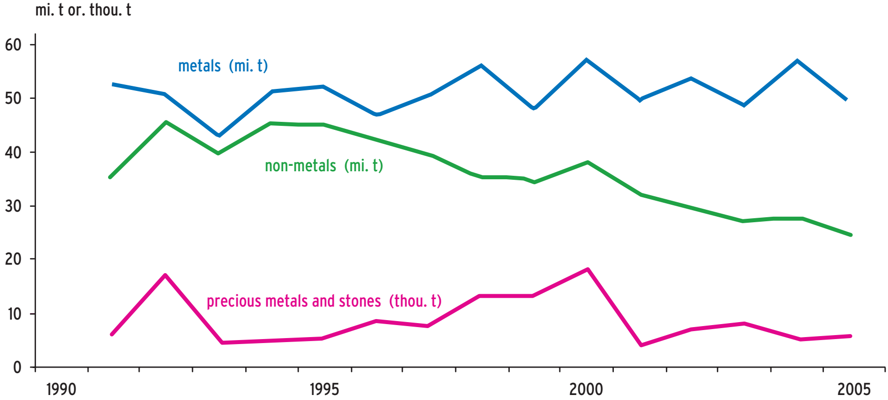
In 2005 some 68.5 mi. t. of limestone, dolomitic rocks and marls were obtained, approximately 48 mi. t. of which was used in the manufacture of cement and quicklime. The 58 cement works are concentrated in the Münsterland Basin, in the Swabian-Franconian Alb and the Mainz Basin, but because there is demand right across the country and due to the limitations on the distance that cement can be transported, other sites can be found where suitable storage facilities exist in virtually all the federal states. Limestone has many different uses in industry and is indispensable as a raw material for the construction materials and building industries. However, many other branches such as the chemical and steel industries require limestone. Limestone and dolomitic rock are also widely used as aggregates in concrete and in highway construction. The fireproofing industry is an additional application for dolomitic rocks.

A wide range of other industrial minerals are mined in Germany, both underground and by the open cast method, including gypsum, anhydrite, kaolin, bentonite, feldspar, barite, fluorite and silica.

[2] In the Federal Statistical Office's production statistics the values for sand, gravel and natural rock are substantially lower (in 2005 they were 165 mi. t, and 152 mi. t. respectively), because these statistics do not include businesses with fewer than 10 employees. However, as in the Federation estimates, the figures shown in this brochure for the amounts extracted include production figures for these smaller businesses.

Raw material imports

German raw material imports



Source: *Federal Institute for Geosciences and Natural Resources 2006 (4)*

Despite its high level of domestic raw material production Germany does not possess competitive reserves of many metals and industrial minerals, making it highly dependent on imports of mineral raw materials. Although for many years now the German metals industry has been notable for its high recycling rates for basic metals, in order to meet demand, in 2005 it again had to supplement the substantial level of production by its own smelting plants with imports.

Germany imports raw materials from many countries and from numerous trading partners. As one of the world's main importers of raw materials Germany is bound by a close network of trading relations. Imports are obtained not only directly from producing countries, in the form or ores, concentrated ores and industrial minerals, but also from countries with their own processing industries (metal from metallurgic plants/refineries), which to some extent do not have their own raw materials base. Apart from recycled raw materials, Germany does not have its own raw materials base as a source of primary metallic raw materials. As is revealed by its import statistics, Germany therefore obtains its supplies from all over the world (see world map).

Between 1991 and 2005 Germany's requirements for metallic raw materials, precious metals and precious stones remained more or less at a constant level. Raw material imports of non-metals (predominantly industrial minerals) reveal a downward trend.

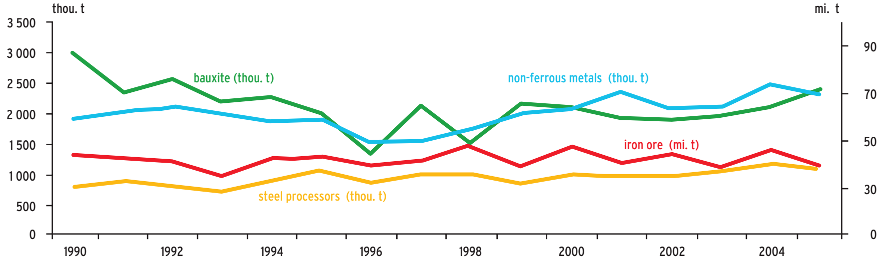
Sources of supply for the import of mineral raw materials

Source: *Federal Institute for Geosciences and Natural Resources 2006*


Czech Rep.
Lignite, hard coal fluorite, graphite
Finland
Zn,Co
Poland
Hard coal, Ag, Pb, natural rock
Russia
Natural gas, crude oil, hard coal, Li, Se, Co, Ni, PGM, W, Au
Slovakia
Magnesite
Ukraine
Ge, Mn
Bulgaria
barite
Kazakhstan
Ag, crude oil
Turkey
Cr, borate
Al
Greece
Crude oil
Syria
China
Hard coal, Mg, Sn, Ge, Mn, Mo, Ta, V, W, SE, barite, fluorite, graphite, magnesite
Libya
Crude oil
Mg
Israel
Phosphate
Jordan
India
Mica, garnet
Co
Taiwan
Sn, W
Vietnam
Hard coal, W
Thailand
W
Ta
Cu, Sn
Indonesia
Zimbabwe
Cr
U, fluorite
Madagascar
Graphite
Australia
Hard coal, U, Fe, Pb, Zn Co, Mn, Ni Ti, Ta, zircon
South Africa
Hard coal, U PGM, Pb, Ge, Cr, Mn, Ti, V, Au, fluorite, zircon

Net imports and total consumption

Net imports of selected metal raw materials



Source: *Federal Institute for Geosciences and Natural Resources, Federal Statistical Office 2006*

Net imports

Germany is a net importer of metallic raw materials. Between 1990 and 2005 net imports of iron ore remained more or less constant, while the materials used for refining steel (chromium, ferromanganese, molybdenum, nickel) recorded a slight increase. Net imports of bauxite (the raw material for aluminium) and non-ferrous metals (copper, lead, zinc, tin) declined from 1990 until around 1995, when they began to increase again slightly. Germany is also a net importer of many industrial minerals. Domestically produced non-metallic raw materials are either used locally or, as in the case of potassium salts which are used to make potassium fertilizer, are processed and subsequently exported.

Total consumption

Within the EU Germany is the largest consumer of metallic raw materials, and also among the leading users worldwide. Between 1995 and 2003, or 2005, total consumption (= domestic extraction + recycling + imports − exports) rose significantly, for example in the case of aluminium, copper, fluorite and graphite. This contrasts with a decline, in some cases quite considerable, in the overall consumption of barite, bentonite, potassium fertilizers, phosphates and magnesite. Growing environmental awareness in particular has led to a noticeable decline in the use of phosphates.

Metallic raw materials: total consumption (1 000 t)

Raw mat.	1995	2003
Aluminium	2 157.82	2 987.22
Lead	384.14	389.36
Copper	1 348.22	1 515.85
Zinc	717.64	720.24
Tin[1]	20.64	20.61
Nickel[1]	96.75	94.35

[1] Only consumed in refined form [2] t K_2O

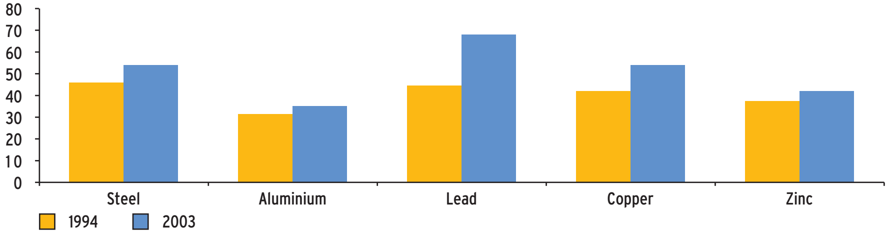
Industrial Minerals: total consumption (t)

Raw mat.	1995	2005
Baryt	330 043	294 096
Bentonite	733 234	586 249
Fluorite	234 274	274 034
Graphite	30 132	44 240
Rock salt	13 572 984	17 886 376
Phosphate	288 553	99 287
Potassium fertilizers[2]	823 000	415 000
Magnesite	509 561	440 360

Source: *Federal Institute for Geosciences and Natural Resources, Federal Statistical Office 2006*

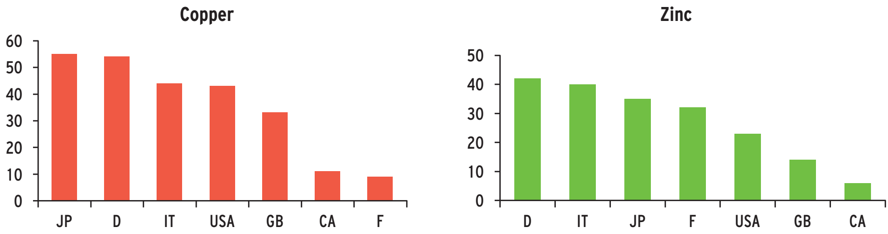
Recycling

Recycling rates for selected metals in Germany
(as % with reference to total consumption)



Source: *Federal Institute for Geosciences and Natural Resources 2005*

Comparison of recycling rates for copper and zinc in several industrialized countries
(as % of total consumption in 2003)



Source: *Federal Institute for Geosciences and Natural Resources 2005*

Germany occupies a leading position in the world in the recycling of metals. Modern technology enables Germany to recycle more than 50 % of its steel, lead and copper, for example. Compared with other industrialized nations Germany is a leader in the recycling of zinc, followed by Italy, while Germany occupies second place for copper.

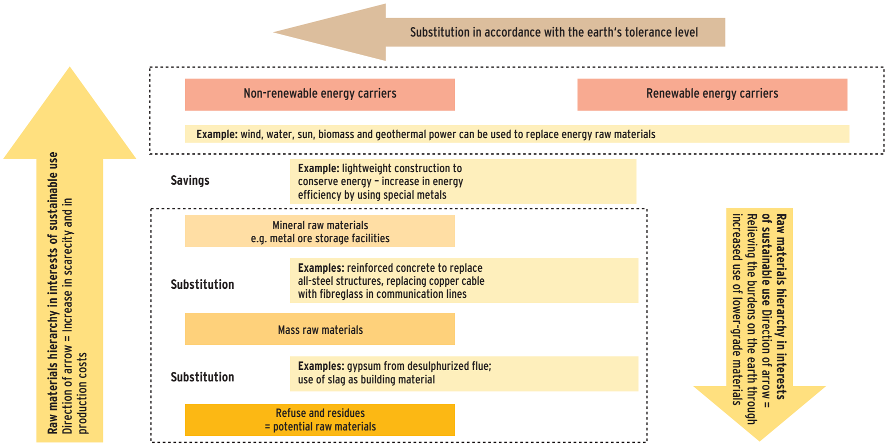
The less a metal is combined with other materials, the easier it is to recycle, and one positive example is provided by the lead in batteries. Glass manufacturing too, in which 94 % of the materials used are obtained from recycled glass, provides a good example of the high degree of efficiency with which secondary raw materials can be used and additional energy can be saved. Solder, on the other hand, which is used in circuit boards, is one material that, when in its scrap state, can only be recycled at considerable expense. Consequently only around 10 % of solder was recycled in 2003.

However, the recycling intensity also depends on the price of the primary raw material, on various aspects of the particular material itself and also, to a great extent, on the technical possibilities and regulatory mechanisms provided by environmental legislation.

The recycling of materials is a relatively new development in the non-metallic building materials sector. The introduction of the Recycling Industry Law in Germany in 1996 means that increased efforts must be made to re-use waste materials in all materials sectors. Corresponding laws and directives now exist in almost all industrialized nations.

Technical developments for reducing the use of materials

Hierarchy of natural resources, with the aim of replacing high value raw materials by those of lower value, and energy raw materials by renewable energy



Source: *Wellmer, F.-W., Kosinowski, M. 2005 (5)*

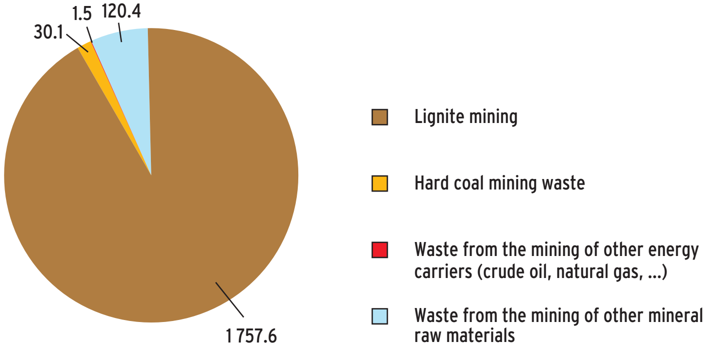
The increasingly economical use of raw materials by industry is a continuous process. For example, the aluminium foil used by the packaging industry is being rolled more thinly to conserve material. Another example of savings on material is provided by the ongoing miniaturization of electronic components such as diodes, capacitors and transistors by a factor of 5 to 10 every decade. The substitution of expensive, high grade raw materials by cheaper ones that can fulfil the same function has an important part to play in industry.

The diagram shows a raw material hierarchy for the sustainable use of such materials. Energy-producing raw materials occupy the highest category, because industry would come to a standstill without them and they can only be replaced by renewable forms of energy. Below them come those raw materials, the extraction process of which is energy intensive and expensive to differing degrees on account of the enrichment processes in the earth's crust. The extraction of metallic raw materials is particularly expensive, followed by that of mass raw materials, which are available in sufficient quantities and are generally easy to obtain. At the other end of the scale are the waste products, which have a potential as raw materials and which may be subsequently usable.

One example of sustainable operations in accordance with this hierarchy is the substitution of iron and steel in structural engineering by reinforced concrete, replacing a metallic raw material by a compound made using a metallic raw material and a mass raw material. The steel content of the structure can therefore be substantially reduced without affecting its function, saving both raw materials and energy. Another example is reducing steel input by the use of modern high-performance steel. The pure steel structure of the Eiffel Tower, which was built in 1889/1890, today would require only 2 000 t of steel instead of 7 300 t.

Non-utilized extraction of abiotic raw and ancillary materials

Non-utilized extraction 2004 in mi. t



Source: *Federal Statistical Office 2006 (6)*

To varying extents the extraction of raw materials also involves the removal of non-usable materials. Mining waste and material resulting from clearance work have to be removed in order to reach the "actual" raw material, altering or even destroying landscapes and ecosystems. Details about the quantity of non-usable materials produced in connection with the extraction of raw materials gives a vague idea of the extent of the environmental damage, but no statements about toxicity are possible.

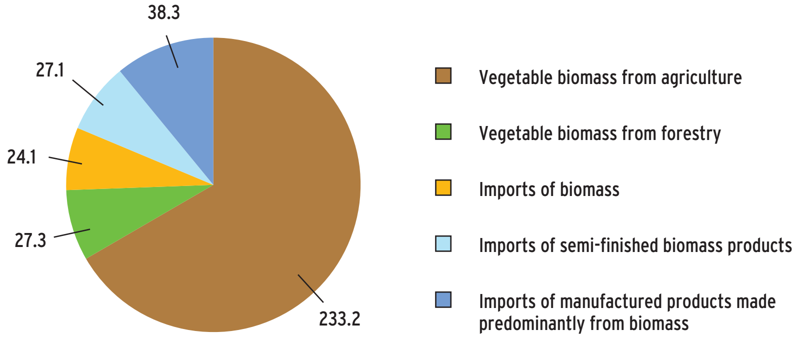
The removal of abiotic raw materials in Germany in 2004 resulted in the creation of some 1 910 mi. t of non-usable material, which is more than twice the amount of usable raw materials (866 mi. t). By far the largest proportion of this was produced during the extraction of lignite (1 758 mi. t) . A further 30 mi. t resulted from the mining of hard coal. Only very limited quantities of ore are extracted in Germany. The extraction of other mineral raw materials created some 120 mi. t of unused materials.

On average, domestically in 2004, the extraction of each tonne of usable, abiotic materials was accompanied by 2.2 t on non-usable material. In terms of the domestically extracted fuels this figure was 7.9 t., with lignite mining being the dominant factor, as has already been mentioned. In the case of mineral raw materials, on the other hand, only 0.2 t of each tonne used could not be exploited.

A large proportion of the raw materials used in Germany are obtained from other countries, for example, in 2004 of all the ores used in Germany, 99 % came from abroad. Among fuels, measured in units of weight, around half of the entire total used came from imports, and if measured in thermal units, the proportion is in excess of three quarters. In these cases the creation of non-used ancillary materials and any environmental pollution associated with the extraction occur in the country where this takes place. Hardly any data is available about unused material accumulating abroad as the result of German imports.

Biotic raw materials

Biotic raw materials 2004 in mi. t



Source: *Federal Statistical Office 2006 (6)*

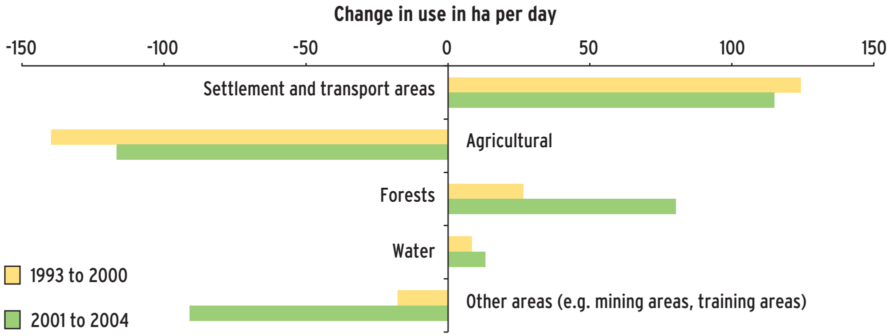
In 2004 some 261 mi. t of biotic raw materials were extracted domestically, which is 15.4 % of all the material deployed by the economy as a whole. Compared with1995, by 2004 the quantities had increased by 37 mi. t., although there were weather-induced fluctuations over time. These results take into account the harvest of agricultural products, biomass for use as livestock feeds, biomass obtained from forestry, catches by the fisheries industry, the results of hunting (quarry) and other forms of biomass, whereas the production of meat, animal products (eggs, milk, skins etc.) and the fish obtained from fish farms are considered to be part of the economic system and are not therefore interpreted as having been obtained from the environment. However, imported goods (primarily) biotic in origin are included to their full extent (i.e. also meat and animal products) among the biotic raw materials. In 2004 they amounted to around 90 mi. t., whereas in 1995 the figure was 70 mi. t.

The most important items by weight are fodder plants (including pastureland) with 92 mi. t in 2004, followed by grain and legumes (52 mi. t.), root crops (40 mi. t.) and biomass obtained from forestry (27.3 mi. t by dry weight).

An area of some 189 000 km^2 is used in Germany for the agricultural production of biotic raw materials (31.12.2004). According to estimates by the Federal Ministry of Food, Agriculture and Consumer Protection, in 2005 some 14 000 km^2 or 7,5 % of agricultural land was used for the production of so-called renewable raw materials, which are used in the non-food sector, human or animal, (for example to produce energy or as a raw material for industrial products). Although the area devoted to agriculture has declined since the end of 1992 (−3 %), those areas used for renewable raw materials (e.g. rape oil, starch, sugar, sunflower oil) have increased considerably, to almost fivefold between 1993 and 2005. Rape cultivation for oil dominated, occupying over 75 % of the cultivated area.

Total land use

Changes in use of land areas 1993 to 2004



Source: *Federal Statistical Office, Federal Environment Agency 2006 (7)*

In 2004 Germany occupied a total area, including the combined German-Luxembourg territory, of 35 704 963 ha. In 2004 an area measuring 18 932 446 ha was being used for agricultural purposes, making agriculture the largest single form of use in terms of area. Compared with 2000 its share of overall land use fell by 0.5 percentage points from 53.5 % to 53.0 %. In the past the decline in the area under cultivation has been a continual process, especially in the vicinity of large, densely populated conurbations. The main reason for this development has been the ongoing increase in the areas occupied by settlements and transport.

In 2004 the area covered by forestry, 10 648 822 ha (29.8 %), was 0.3 percentage points more than in 2000, when it accounted for 29.5 %. Its expansion was achieved above all at the expense of other areas, and in particular those formerly used by the military (training grounds) and areas of unspecified use. There are small woodlands in the centres of the large and densely populated conurbations and in areas of intensive agricultural use, occupying less than 20 % of the total area.

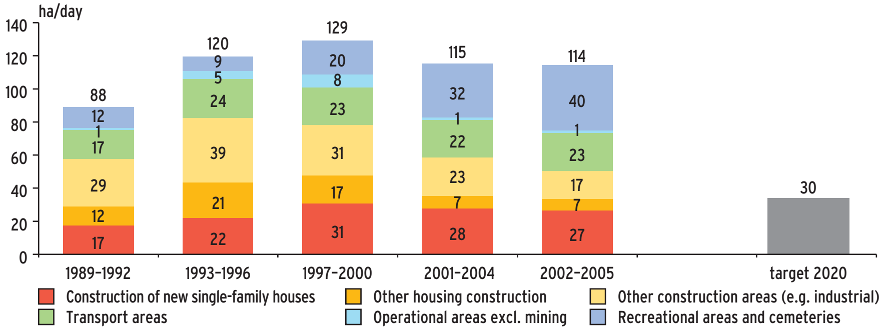
In 2004 areas of water measured 827 903 ha, which was 2.3 % of the surface area of Germany. The 2.4 %, 19 441 ha, increase in areas of water was due above all to the extraction of raw materials such as gravel, sand and lignite, followed by the flooding of the extraction site, leading to the creation of post-mining landscapes containing new lakes.

In 2004 the area occupied by settlements and transport accounted for 4 562 075 ha or 12.8 % of the total surface area in Germany. This is a rise of 0.5 percentage points compared with 2000, making settlement and transport areas the third largest type of land usage in Germany, but the one with the most dynamic growth. There are substantial regional differences in the density of settlement and transport areas throughout Germany. In downtown areas (such as those of Dortmund, Essen, Duisburg) in densely populated conurbations (e.g. the Ruhr area) its share can exceed 50 %.

In 2004 other areas, such as those used for mining or for training purposes, were the smallest category in Germany, accounting for 2.1 % (733 718 ha) of the total surface area [2].

Settlement and transport areas

Daily increase in settlement and transport ares[1) – causes and responsibility for increases



1) Data for new *Länder* 1989–1992 has been estimated by Federal Environment Agency; construction of new single family homes, other housing construction, other construction areas: buildings and open spaces

Source: *Federal Statistical Office, Federal Environment Agency 2006 (8)*

In 2005 the area occupied by settlements and transport in Germany amounted to 4 605 043 ha compared with 4 030 524 ha in 1992. This expansion has mainly taken place at the expense of areas used for agriculture.

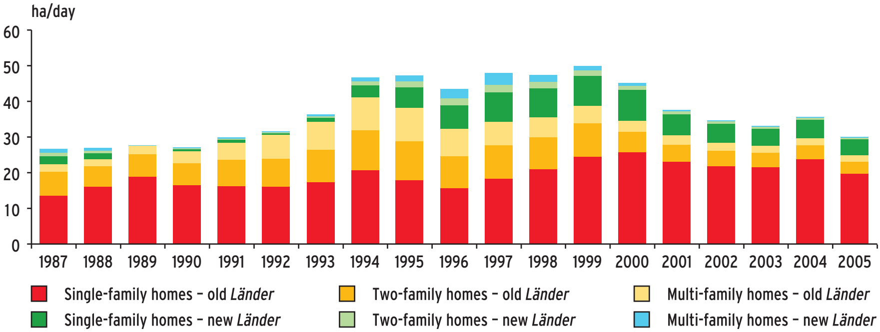
The 88 ha per day increase in these settlement and transport areas in Germany can only be estimated for the period from 1989 to 1992 because statistics relating to land areas are only available for the old *Länder*. Following reunification and the subsequent adaptation of planning and construction system in the new *Länder* to comply with federal German law, from 1993 onwards the amount of land being newly utilized each day in the old *Länder* and the new *Länder* increased at the same rate and reached its maximum of 129 ha between 1997 and 2000. Subsequently the amount of new land being utilized daily fell to 114 ha between 2002 and 2005. The nationwide increase in settlement and transport areas between 2002 and 2005 can be divided into roughly 75 ha per day in the old *Länder* and around 39 ha daily in the new *Länder* (including Berlin).

The rate of expansion of the area occupied by buildings and associated greens, which accounts for more than half of the increase in settlement and transport areas, is clearly slowing down. Expansion of areas devoted to transport has been disproportionately low over the last four year period at only around 2 %. However, an adverse environmental impact is also associated with even such a slow rate of expansion, including noise pollution and the continued fragmentation of open spaces in particular [3]. Half of the area occupied by settlements and transport is sealed, an area of 2.3 million ha or 6.4 % of the total land area of Germany.

The intention is to reduce the expansion of settlement and transport areas to 30 ha per day by 2020 [4]. However, there is still some way to go before the government's objective, as stated in the National Sustainability Strategy [5], can be achieved. Moreover the Sustainability Council is demanding that the amount of new land being taken over for settlements and transport should be reduced to zero by 2050, in particular by recycling of brown fields.

Housing areas

Increase in housing area as result of increase in housing stock
(new *Länder*: data for 1994 has been interpolated from 1993 and 1995)



Source: *Federal Statistical Office, Federal Environment Agency 2006 (8)*

The construction of housing is a major reason for the continuing expansion of the area occupied by settlements.

Compared with the initial situation in the two years preceding reunification, little change occurred in housing construction in the old *Länder* until 1991, while in the new *Länder* it declined significantly as the result of the frictions during the changeover to a different system.

During the 1990s, beginning in the old *Länder* and later in the new *Länder* (including Berlin), building activity increased sharply, especially the construction of multi-storey dwellings. In the old *Länder* this was to meet the needs arising from the migration of some 4 million people in just six years, combined with the large number of young adults leaving home who were born during the population bulge of the 1960s.

During the first few years following reunification there was a backlog in the number of dwellings needed in the new *Länder*, although this has now been completely eliminated by the construction of new homes and also as a result of the outward migration of working people. There are currently over one million empty dwellings in the new *Länder.* The amount of unoccupied housing is now increasing also in those parts of the old *Länder* that lie outside the main growth areas and where a large proportion of the population are elderly.

As the wave of migration has died down, the number of new dwellings constructed in Germany over the past ten years has steadily fallen from just under 570 000 in 1995 to 210 000 in 2005. However, there has been a shift in building activity from multi-storey dwellings, which make relatively economical use of the available space, to single-family houses which require more space. Consequently, and despite a decline in the number of dwellings completed after 1995, housing demand initially continued to take up even more land, reaching a maximum of 49 ha per day by 1999.

The recycling of derelict land

The new utilization of greenfield sites takes place at the expense of valuable natural resources, which were previously mainly devoted to agriculture. During the period from 2002 to 2005 the area occupied by settlements and transport grew by 114 ha per day, due not to a population increase but to the increasing amount of land consumption per person. In 1950 the per capita living area was 15 m^2 compared with 40 m^2 today [6].

Despite the high rate at which open spaces are being occupied, the amount of derelict land is increasing too. From the end of 1996 to the end of 2000 alone the daily increase in cities and towns was approximately ten hectares, rising from 128 000 ha to 139 000 ha, which corresponds to four years' supply of the land required for settlement expansion.

The German government's National Sustainability Strategy is intended to restrict the amount of new land being claimed daily for settlement and transport purposes to 30 ha by 2020, which is roughly equivalent to the area of 41 football pitches every day. In view of the government's land conservation objective the re-use of derelict sites in urban areas is essential.

One conceivable aim would be to meet the demand for land for new uses by utilizing existing derelict sites, with a figure of

- 25 % from the present,
- 50 % in 2010,
- 75 % in 2020

The intention is that newly designated settlement areas as a proportion of the area required for new settlements should fall from 75 % in 2000 to 25 % in 2020. The regional availability of derelict sites and the regional demand for land, e.g. due to migration, should be taken into account when preparing regional site objectives [7].

Source: *Federal Environment Agency, photograph Busse (9)*

In efforts to encourage the recycling of derelict areas it is essential that only a limited amount of land is made available for building. Regional surpluses, especially of greenfield sites, force the price for building land down and redirect demand away from well integrated, inner-city gap sites and derelict land.

Mining areas for the extraction of raw materials

Calculation and comparison of the areas used for extracting raw materials in 1997 and 2004[1)]

		Tonnage 1997 t	Tonnage 2004 t	"Density" t/m³	Ø Thickness m	Equivalent area 1997 km²	Equivalent area 2004 km²
Construction raw materials	Building sand, gravel etc.	374 500 000	278 900 000	1.80	15.00	13.87	10.33
	Quartz sand	13 500 000	11 600 000	1.80	15.00	0.50	0.43
	Broken natural rock	203 000 000	170 000 000	2.60	25.00	3.12	2.62
	Limestone and dolomite	72 100 000	74 100 000	2.60	25.00	1.11	1.14
	Limestone for cement	42 400 000		2.60	25.00	0.65	
	Clays	30 200 000	4 400 000	2.20	10.00	1.37	0.20
	Unprocessed kaolin	4 100 000	3 800 000	2.20	10.00	0.19	0.17
	Gypsum and anhydrite	4 800 000	1 600 000	2.00	10.00	0.24	0.08
	Bentonite		405 000	2.20	1.50		0.12
	Pumice			0.80	5.00		0.02
	Natural cut stone		229 000	2.60	5.00		0.02
	Intermediate total:	**744 600 000**	**54 034 000**	–	–	**21.05**	**15.11**
Energy-providing raw	Lignite, Rheinland	99 200 000	100 286 000	1.30	35.00	2.18	2.20
	Lignite, Lausitz	59 400 000	58 996 000	1.30	11.00	4.15	4.13
	Lignite, central Germany	14 400 000	20 248 000	1.30	11.00	1.01	1.42
	Lignite, Lower Saxony/ Helmstedt	3 900 000	2 372 000	1.30	20.00	0.15	0.09
	Lignite, Hesse		0	1.30	10.00		0.00
	Lignite, Bavaria		23 000	1.30	10.00		0.00
	Peat[2)]			–	1,50/2.00	6.67	4.80
	Intermediate total	**176 900 000**	**181 925 000**	–	–	**14.16**	**12.64**
	Sum total					**35.21**	**27.75**

[1)] 2004 data supplemented by authors [2)] Peat 1997 = 10 000 000 m³; 2004 = 9 602 000 m³

Source: *Gwosdz, W., Röhling, S. 2003 (10)*

The mining of raw materials close to the surface, and of non-metallic building materials and lignite, inevitably takes up the land where these materials are found.

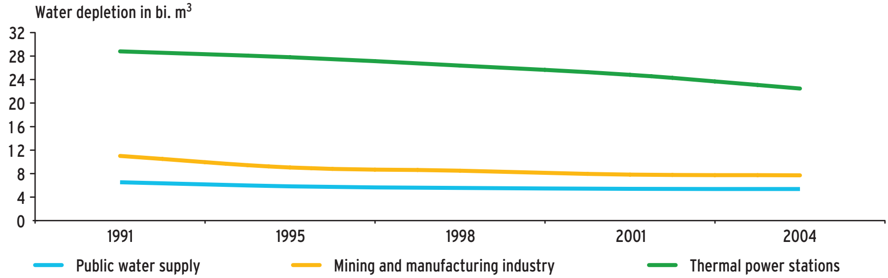
For 2004 the Federal Statistical Office designated approximately 0.5 % of the land area of Germany as "mining land". The official land register that forms the basis for compiling the relevant statistics uses the term "mining land as an operational area" in referring to undeveloped areas which are primarily utilized for the extraction of substances from the ground. These consist of sand, gravel, loam, clay, marl, rock, ore, coal, peat and lava. Also included are area which have been prepared for mining, partially exploited areas and safety strips. Accordingly this 0.5 % of the entire land area of Germany covers 1 764 km^2.

According to calculations by the Federal Institute for Geosciences and Natural Resources, referring to information about equivalent areas, the equivalent area for the quantity of raw materials used in 2004 amounted to 27.75 km^2. In relation to the total land area of Germany (357 050 km^2) this gives a percentage of 0.0078 % for the proportion of actual area mined annually. Compared with 34.02 km^2 in 1997 the annual area of land being utilized has therefore declined significantly. The area of land being utilized daily for the extraction of raw materials fell from 9.3 ha in 1997 to 7.6 ha in 2004.

Compared with areas used for settlements and the construction of transport routes, the areas from which mineral raw materials are extracted close to the surface are not occupied over an extended period of time. Once extraction has been completed and the site has been restored in accordance with statutory requirements, i.e. returned to nature and recultivated, it becomes available again to society for other purposes after a few decades.

Water balance

Water extraction in Germany



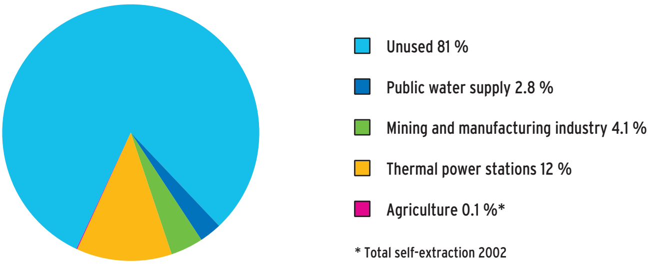
Source: *Federal Statistical Office 2006 (11)*

With 188 billion m^3 of available water Germany has extensive water resources. The potential water availability indicates the utilizable quantities of groundwater and surface water. This figure represents a balance, which is obtained from the amounts of precipitation and evaporation, as well as from the amounts flowing to and from neighbouring countries.

In Germany the main areas of industry and private households which are connected to the mains supply only use approximately 19 % of the available water resources. Over the past 15 years there has been a noticeable decrease in the amount of water extracted in all areas, which totalled 35.6 bi. m^3 in 2004. The largest proportion (corresponding to 12 % of the available water), amounting to 22.5 bi. m^3, was used by thermal power plants for the public energy supply. The public water supply, which provides drinking water for households and small businesses, only used around 2.8 % of the available water, a total of some 5.4 bi. m^3.

The per capita figure is the initial indicator of whether the amount of available water is sufficient to supply requirements. In 2004 approximately 2 278 m^3 of useable water per head was available to Germany's population of 82.5 mi. This is equivalent to a potential amount of 6 241 l per head per day.

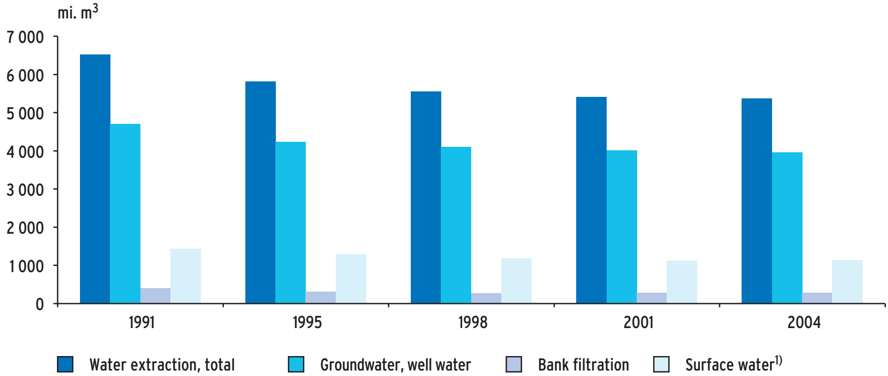
Water supplies and water use in Germany 2004



Source: *Federal Statistical Office 2006 (12)*

Water from the public supply

Water extraction by public water supply sector according to types of water



[1] Water in lakes or barrages, river water and replenished groundwater (scheduled percolation of surface water, genuine groundwater and possibly bank filtration)

Source: *Federal Statistical Office 2006 (13)*

In Germany there are 6 383 companies (including 5 043 companies undertaking their own extraction) providing public water supplies. They mainly obtain drinking water from groundwater and wells (73.5 %). The remainder of the water supply is obtained from surface water and bank filtration.

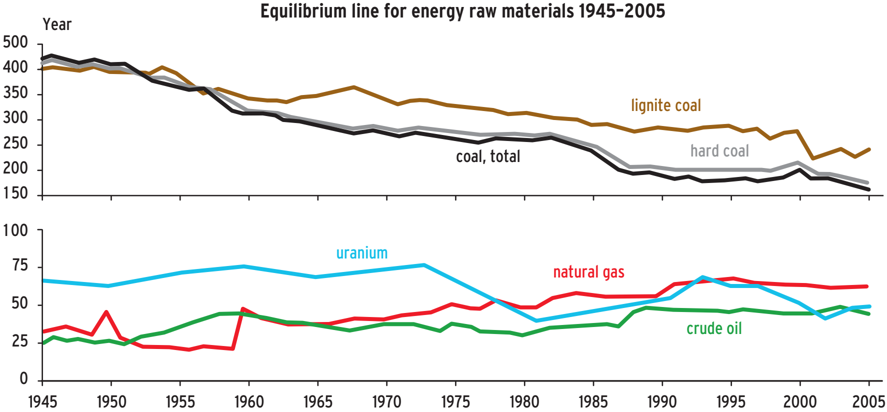
In 2004 the ultimate consumers received 4 728.7 mi. m^3 of water from the public supply – private households and small businesses 3 752.3 mi. m^3, commercial and other users (schools, public sector authorities and hospitals) 976.3 mi. m^3 of water. The past 13 years have seen a decline of around 17.7 % in the amount of water supplied.

Water loss gives an indication of the state of the water supply infrastructure, and it declined noticeably by 34 % between 1991 and 2004. In 2004 water losses amounted to around 495 mi. m^3, corresponding to 6.8 % of the total amount produced by the public water supply. Compared with the rest of Europe this is a low rate of loss.

Average water consumption varies widely from one federal state to another. Whereas in 1991 water consumption in the new *Länder* and East Berlin, at 139 l/p.c.*d differed only slightly from that of the old *Länder*, where it was 145 l/p.c.*d, by 2004 there were significant differences: In that year water consumption in the western states averaged 132 l/p.c.*d, compared with just 93 l/p.c.*d on the east (excluding Berlin). The lowest figure of any of the federal states was that of Saxony, with 88l/p.c.*d. while Schleswig-Holstein and Hamburg had the highest consumption in 2004 at 142 l/p.c.*d. Saxony-Anhalt achieved a significant reduction in the amount of water consumed by private households and small business, where the amount of drinking water used fell by 42.8 %, from 161 l/p.c.*d in 1991 to 92 l/p.c.*d in 2004.

Global availability of non-renewable energy raw materials worldwide

Development of static range of energy raw materials (reserves) over the past 60 years



Source: *Federal Institute for Geosciences and Natural Resources 2006 (3)*

At the end of 2005 the reserves, i.e. the non-renewable energy raw materials currently obtainable technically and economically around the world, amounted to some 1 300 Gt of coal equivalent (CE). In terms of quantity coal is the dominant energy raw material, accounting for some 55 % of the reserves of all non-renewable energy raw materials. Crude oil is second with around 26 %, followed by natural gas with 15 %, and all nuclear fuels together make up just over 4 %.

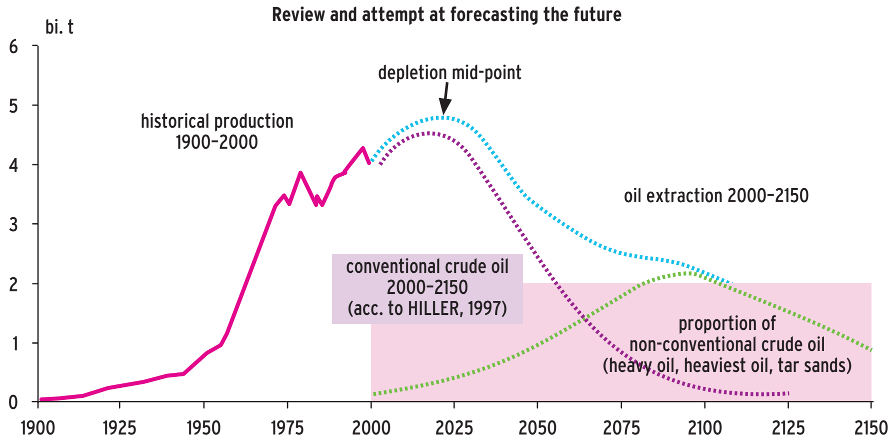
Around the world at the end of 2005 the resources, i.e. the current amounts of non-renewable energy raw materials that are proven but are currently not technically and/or economically obtainable, and the future quantities that are unproven but geologically feasible, amounted to some 6 500 Gt CE. Among resources the dominant position of coal, at over 60 %, is even more pronounced than it is in the case of the reserves. At 29 % the aggregated resources of conventional and non-conventional natural gas (3.5 % and 25.6 %) rank second. They are followed by crude oil with just over 7 %, ahead of nuclear fuels with slightly more than 3 %.

In a comparison of hard coal, and lignite too, with other traditionally used fuels, i.e. crude oil, natural gas and uranium, one cannot help noticing that these two types of coal embody a much more satisfactory situation in terms of their worldwide geological availability. Whereas the proven reserves of crude oil, uranium and natural gas are between 40 and 70 times greater than the current worldwide annual consumption, in the case of hard coal the equivalent figure is in excess of 140 years, and well over 200 years for lignite. Moreover coal reserves are much more evenly distributed around the world than those of crude oil or natural gas. Around 70 % of the reserves of conventional crude oil and natural gas are found within what is known as the "strategic ellipse", stretching from the Middle East to Northern Russia.

Apart from conventional crude oil, the global reserves of energy raw materials are expected to be sufficient to meet long term energy requirements. In the case of crude oil, once the point of maximum extraction, "peak oil", has been reached in ten to fifteen years, we can expect demand to outstrip supply, a shortfall that will have to be made up by the use of other fuels or crude oil substitutes.

Crude oil is virtually the only raw material for which it is possible to state not only a depth limit for the formation but also, because crude oil migrates along a pressure gradient, normally acting against gravity, a limit to the depth of the storage rock too. The world's large sedimentary basins are well known and, based on experience gained by the oil industry, the largest deposits tend to be discovered earliest, contrary to the situation in ore exploration consequently the geological potential for the existence of conventional crude oil can be gauged with considerable accuracy.

Depletion mid-point of worldwide oil extraction

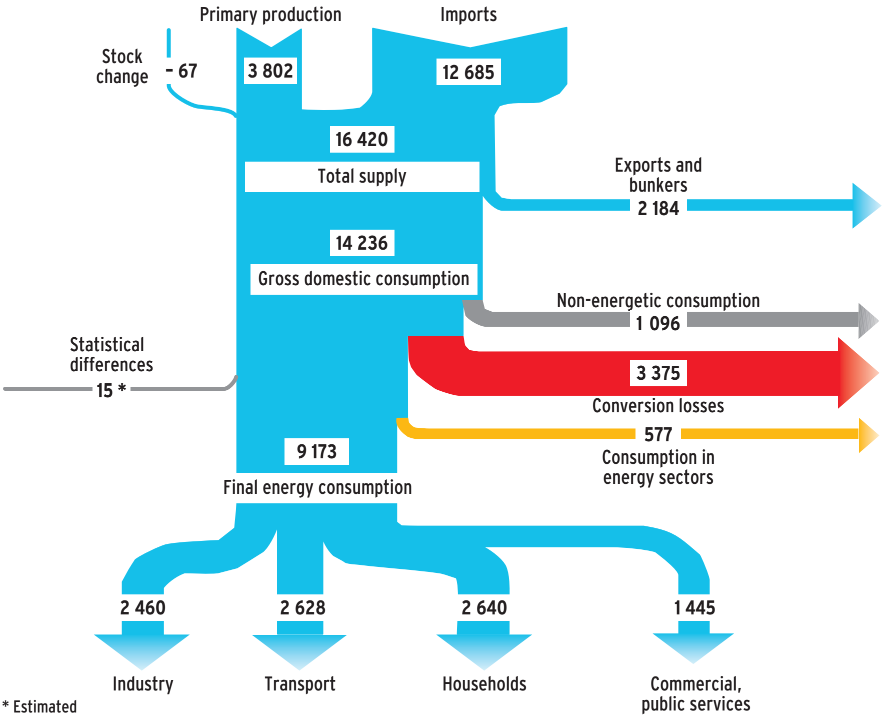


Source: *Federal Institute for Geosciences and Natural Resources 2006*

The "depletion mid-point" for crude oil, which is derived from the curve showing the life cycle of oil, i.e. to a point in time at which no further increases are possible in the amount extracted, will be reached between 2010 and 2020. From this time onwards at the latest the price level will rise significantly, with the result that even unconventional oil resources such as heavy oil and deposits of oil shale, as well as tar sands and possibly coal liquefaction too, will become economically viable.

Energy flows

Energy flow diagram for Germany 2005 in PJ

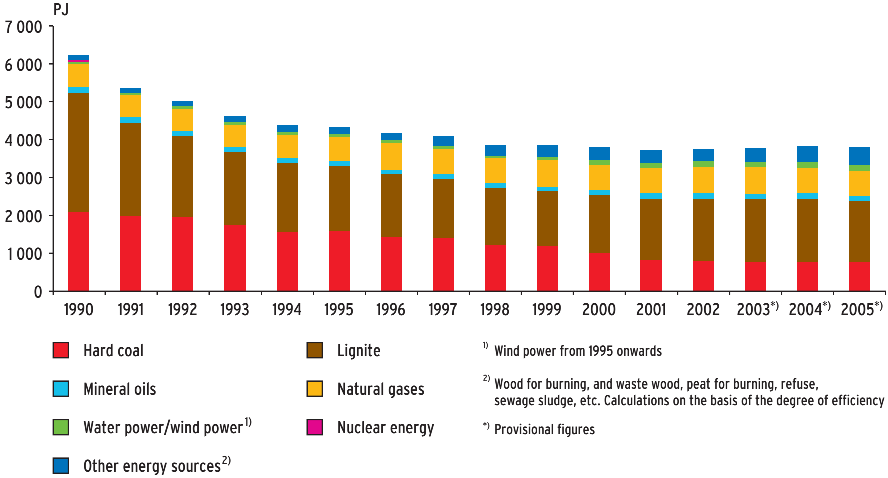


Source: *Working Group on Energy Balances 2006 (14)*

This diagram shows the composition and distribution of energy flows in Germany in 2005. Approximately a quarter of Germany's energy demand is obtained domestically, the remaining three quarters being imported. Corrected to reflect changes in stock, and not including exports and bunkering, consumption of primary energy in 2005 was 14 236 PJ. If consumption for non-energy purposes, conversion losses, own use of the energy sector and statistical differences are discounted, a final energy consumption figure of 9 173 PJ is obtained. Here the large proportion represented by conversion losses (just under 24 % of the primary energy consumed) in the energy sector, which is accounted for by the generation and provision of secondary energy sources such as electricity and useful energy, is clearly evident. Final energy consumption can be divided among the sectors of industry, transport, households and commercial/public services. The following articles deal with the aspects referred to in more detail.

Primary energy production according to energy sources

Development of the production of primary energy in Germany according to energy sources



Source: *Working Group on Energy Balances 2006 (15)*

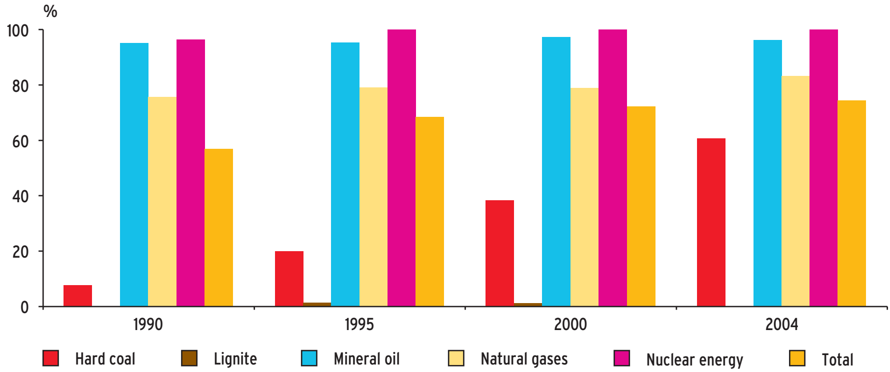
There was a 39 % decline in the extraction of domestic primary energy in Germany between 1995 and 2005, from 6.224 PJ to 3.802 PJ. Currently the most widely used domestic fuel is lignite, which achieved a 42 % share in 2005 (1990: 51 %). The mining of hard coal accounts for just under 20 % of domestic extraction (1990: 34 %), having experienced a decline of – 64 % over the past 15 years. During the period under consideration there has been a slight rise in the extraction of natural gas (+ 11 %), and at 656 PJ it makes up 17.3 % of extracted primary energy (1990: 9.5%). Due to a lack of domestic reserves domestic extraction of crude oil is no longer of any relevance in Germany, and in 2005 it amounted to a 3.9 % share. Although the contribution made so far by water power and wind energy to primary energy production in Germany is small, nevertheless it has risen by 191 % since 1990, from 58 PJ to 169 PJ. Over the same period other sources of energy, from biomass, waste and solar power, increased during the same period by 264 %, from 128 PJ to 466 PJ. For example, from 2004 onwards the amount of energy obtained from water and wind power exceeded that derived from extracted crude oil.

As the trend described above reveals, the reserves of non-renewable primary energy, comprising the quantities that, technically and economically, can currently be extracted, are declining, and the reduction in domestic production is being compensated for by increased imports of energy products. At the same time the vast potential offered by domestic renewable energy sources is being exploited to a growing degree.

Primary energy imports

Share of primary energy consumption

Primary energy imports by Germany according to energy sources



Source: *Working Group on Energy Balances 2005 (16)*

Net Imports as % of Primary energy consumption
(Primary energy consumption as Proportion of Sum of Imports less Exports less Bunkers)

	1990	1991	1992	1993	1994	1995	1996	1997
Hard coal	7.7	12.3	16.9	16.6	18.3	19.9	24.0	30.2
Lignite	−1.0	0.8	1.5	1.6	1.5	1.4	1.5	1.5
Mineral oil	95.0	96.5	98.1	95.5	96.5	95.3	96.5	96.5
Natural gases	75.6	75.3	77.4	77.8	79.4	79.0	80.0	81.2
Nuclear energy	96.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	**56.8**	**62.2**	**66.4**	**66.6**	**67.9**	**68.5**	**70.5**	**71.8**

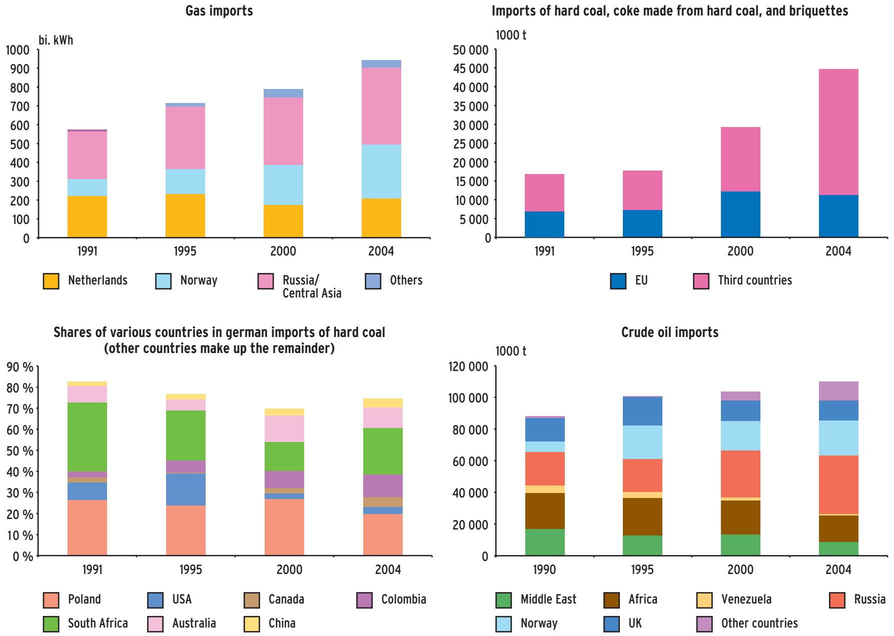
	1998	1999	2000	2001	2002	2003	2004
Hard coal	36.0	40.1	38.2	49.1	56.6	56.3	60.7
Lignite	1.5	1.6	1.1	1.1	0.1	−0.6	−0.7
Mineral oil	100.2	94.6	97.2	98.3	96.2	98.1	96.1
Natural gases	77.8	80.5	78.9	77.5	80.3	78.3	83.2
Nuclear energy	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	**73.5**	**72.6**	**72.2**	**73.7**	**73.5**	**73.6**	**74.4**

Source: *Working Group on Energy Balances 2005 (16)*

Germany's own reserves of primary energy sources are very small, making it highly dependent on the import of energy sources. Over the past 15 years imports have risen from 56.8 % to 74.4 % (not taking into account stocks of uranium, its natural compounds and radioactive isotopes). As a consequence only one quarter of the primary energy consumed is met from domestic energy sources. Since 1991 100 % of the uranium required for nuclear energy purposes has been imported. Almost all the crude oil is also imported (2004: 96.1 %). For natural gas and hard coal the proportion of imports is 83.2 % and 60.7 % respectively. In contrast, throughout the same period lignite requirements have mostly been met in full by domestic extraction. In fact, in some years the amount of lignite mined has exceeded the demand, enabling some of it to be exported.

Energy imports by country of origin

Energy imports by country of origin



Source: *Working Group on Energy Balances 2005 (16)*

Between 1991 and 2004 imports of gas rose from 573 bi. kWh to 942 bi. kWh. Whereas initially the main exporters were still the Netherlands and the states of the former Soviet Union, by 1999 Norway had become the second most important supplier of natural gas. Thus by 2004 96 % of the natural gas exported to Germany came from three countries (43 % Russia/Central Asia, 31 % Norway, 22 % Netherlands).

Since 1992 imports of crude oil have remained at a relatively constant level, although there have been slight shifts in the sources of supply. Whereas in 1990 26% of crude oil came from Africa – from Libya, Nigeria and Algeria in particular -, 24 % from Russia, 19 % from the Middle East and 17 % from the United Kingdom, by 2004 Russia had become the main exporter, with 34 %, followed by Norway (20 %) and Africa – and Libya in particular. Only 8 % of the crude oil was obtained from the Middle East by 2004.

In order to compensate for the decline in the amount of coal being extracted domestically, since 1996 there has been a continual increase in the import of hard coal, coke, and coal briquettes. Over time imports from outside the EU have risen. Whereas there were two main sources of imports in 1991 (South Africa with 33 % and Poland with 26 %), over the years Australia and Colombia have also become important suppliers of coal to Germany's industries.

Development of energy prices

Development of energy prices in Germany

	Unit	1991	1995	2000	2005*
Import prices					
Crude oil	EUR/t	129.2	94.92	227.22	298.22
Natural gas	Cent/m³	8.54	6.17	9.15	13.37
Hard coal	EUR/t	46.05	40.63	41.54	57.27
Consumer prices					
Light heating oil, households[1)]	EUR/100 l	26.38	21.94	40.82	51.62
Natural gas, households[1)]	Cent/m³	31.27	30.71	34.7	46.05
Electricity, households[1)]	Cent/kWh	14.8	16.36	14.92	18.22
Heavy heating oil, industry[2)]	EUR/t	114.7	106.75	188.92	181.44
Natural gas, industry[2)]	Cent/m³	14.33	12.45	16.72	–
Electricity, industry[2)]	Cent/kWh	6.91	6.74	4.4	–
Normal petroleum	EUR/l	0.65	0.77	0.99	1.1
Diesel fuel	EUR/l	0.55	0.58	0.8	0.98

* Provisional figures [1)] Incl. VAT. [2)] Excl. VAT

Source: *Federal Ministry of Economics and Technology 2005 (17)*

The import prices of crude oil, natural gas and hard coal have risen in recent years. Between 1991 and 2005 the price of crude oil rose by as much as 230 %. In the short term the cost of crude oil has been forced up as a result of conflicts in the Middle East, especially the war in Iraq, Hurricane Katrina in 2005, which adversely affected the pumping of oil in the Gulf of Mexico and refining in the USA, and speculation on the oil futures markets. In the long term the increasing scarcity of the amounts that it is technically and economically feasible to extract, combined with an increased demand for crude oil, not only by the industrialized nations but also by less developed countries, will lead to further increases in the price of this energy source. Gas prices, which are linked to changes in the price of oil, tend to follow these changes, with roughly a six-month delay.

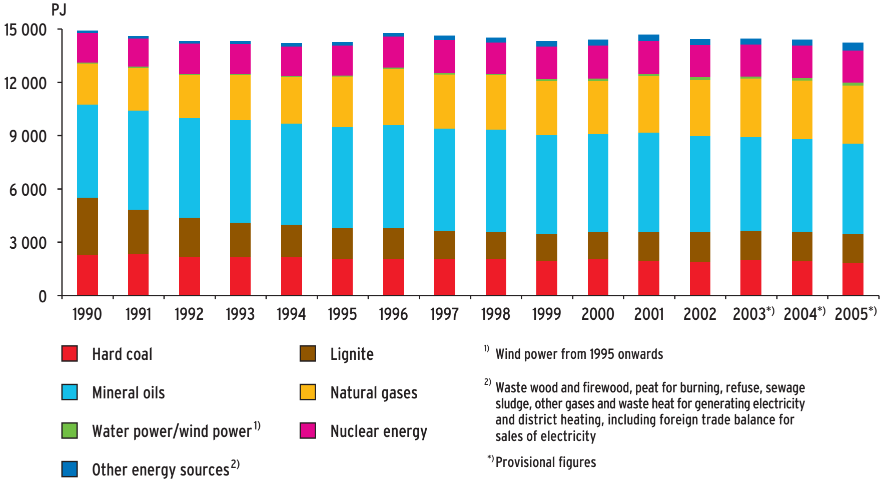
Over the same period, because of its wider geopolitical distribution, the cost of coal imports has fluctuated far less than oil prices.

Consumer prices for the different energy sources also rose between 1991 and 2005, as a result of higher import prices, a lack of competition on the electricity and gas markets, and fiscal policy (the taxes on oil products, gas and electricity, depending on the particular group of consumers).

In 2005 a breakdown of the cost of one kWh of electricity in the domestic sector (0.186 euros) was as follows: generation/transport/distribution 61 %; concession charges 10 %; electricity tax 11 %; contribution in accordance with the Law for the Maintenance, Modernization and Expansion of Combined Heat and Power (KWKG) 2 % and the Renewable Energy Law (EEG) 3 % as well as sales tax 14 %. Increases in the price of electricity since 2001 have mainly been due to the higher costs of generation/transport/distribution (between 59 and 93 % annually), whereas the rise due to the two laws, EEG and KWKG, was relatively slight, at between 7 and 18 % [8].

Primary energy consumption according to energy sources

Development of consumption of primary energy in Germany according to energy sources

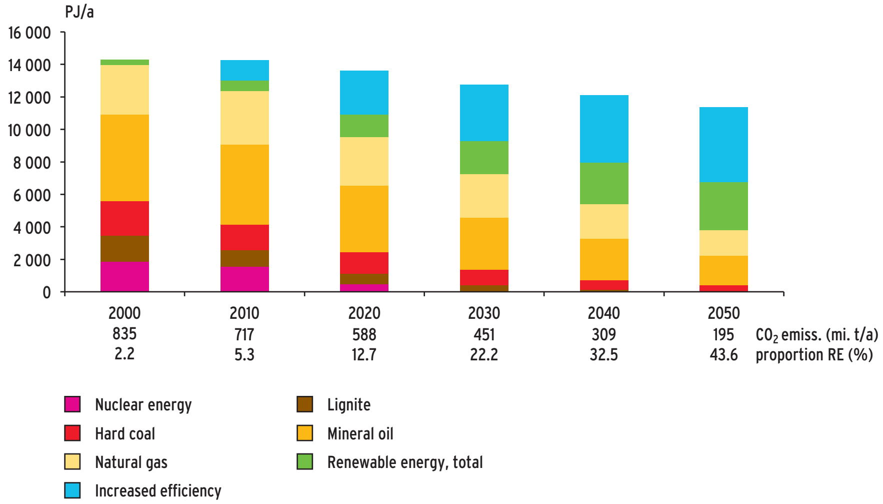


Source: *Working Group on Energy Balances 2006 (14)*

Despite the general economic growth, primary energy consumption in Germany has displayed a slight downward trend since the early 1990s. Today it is 4.7 % below the 1990 figure. Fluctuations in the downward trend in past years can be mainly attributed to the weather, because cold winters lead to a substantial increase in the demand for heating. The decoupling of economic growth from the consumption of primary energy, as can be observed in Germany, is not the general rule elsewhere in the world.

In 2005 the consumption of primary energy in Germany totalled 14 236 PJ, of which 36 % was obtained from mineral oil products, 23 % from natural gas, 13 % from hard coal and 11% from lignite. Nuclear energy met 13 % of total primary energy demand. The proportion of renewable energy sources, which include water power, wind power, geothermal energy, biomass and solar energy, has risen significantly since 1990, reaching 4.6 % by 2005. Since 1990 the biggest changes in the mix of energy sources has been the reduction by half in the amount of lignite used (between 1990 and 1997, after which time lignite consumption remained at a relatively constant level) and the increase of around a third in the amount of gas that was used.

Structure and extent of primary energy consumption in development scenarios



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004 (18)*

This diagram shows a possible scenario as prepared in the report on "The ecologically optimized increase in the use of renewable energy in Germany", commissioned by the Federal Ministry of the Environment, Nature Conservation and Reactor Safety. It describes how the increased use of renewable energy, together with a significant rise in energy efficiency, both during the conversion process and in the form of the energy available to the end user, as well as the increased use of combined heat and power systems, can lead to a substantial reduction in the demand for primary energy.

As the diagram shows, according to this scenario primary energy consumption would decline by about 50 % by 2050, with a particularly sharp fall in the use of coal and mineral oil. Following the complete renunciation of the use of nuclear energy (by approximately 2023) it would not contribute any further to the generation of electricity. In this scenario natural gas would have an important role to play as part of a transitional solution in Germany. Because roughly 90 % of the natural gas being used at present is for heating, the efforts to make greater use of it in electricity generation mean that heating supplies must become less reliant on natural gas in the future. Some significant possibilities exist in the transport sector too for achieving energy savings and helping to protect the climate, such as the introduction of more vehicles with a lower fuel consumption, increased pedestrian and cycle traffic and more public transport, limits on the growth of traffic, and support for fuels that are less harmful to the climate and the environment. According to this scenario, by 2050 almost 50 % of the primary energy consumed would be obtained from renewable energy sources, which would be used to generate electricity and heat and to produce fuel.

Structure of energy consumption

Structure of primary and final energy consumption in Germany

	1990	1995	2000	2005*
	Proportion of primary energy consumption as %			
Consumption and losses in the energy sector	30.0	27.9	28.5	27.9
Non-energetic consumption	6.4	6.8	7.4	7.7
Final energy consumption	63.6	65.3	64.1	64.4
	Proportion of final energy consumption as %			
Industry	31.4	26.5	26.2	26.8
Transport	25.1	28.1	29.3	28.7
Households	25.1	28.5	28.0	28.8
Commercial, public services	18.4	16.9	16.0	15.7

* Provisional figures

Source: *Working Group on Energy Balances 2006 (15)*

Around two thirds of the primary energy consumed in Germany occur in the final energy sectors. The proportion of consumption for non-energy purposes, e.g. the use of oil and other energy sources for the manufacture of road pavings and lubricants, has increased by 7.7 % in recent years. However, own consumption and losses in the energy sector have declined and in 2005 accounted for only 28 % of the primary energy consumed. Substantial changes can be observed in the final energy consumption of different sectors. Whereas in 1990 industry (mining, and the processing industries) was the largest consumer, its importance declined until 2005. Its proportion of the total consumption of final energy fell from 31.4 % in 1990 to 26.8 % in 2005. In contrast there was a sharp increase in the importance of private households, whose share rose from 25.1 % to 28.8 % over the same period. A similar development was apparent in the transport sector (from 25.1 % in 1990 to 28.7 % in 2005).

Development of energy-related greenhouse gas emissions, objectives and measures

Since 1990 Germany has significantly reduced the amount of greenhouse gases that it releases. Using the base year of the Kyoto Protocol as a reference point, by 2004 total emissions, converted into CO_2 equivalents, fell by some 217 mi. t. or 17.6 %. This means that, up to the period 2008 to 2012, there will still be a shortfall of 3.4 % compared with the Kyoto target. A comparative assessment of the effects of these gases on the climate can be made using CO_2 equivalents, which take into account the specific greenhouse potential of each greenhouse gas, in particular of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and the so-called F gases (fluorohydrocarbons).

By far the largest contributor to emissions of greenhouse gases is the energy sector (including transport), which was responsible for 81.5 % of all emissions in 2004. Due to the above-average rates of success in reducing levels in other areas, there has been a slight increase in the relative significance of this source group. This development is closely linked with CO_2 emission values. This gas accounts for some 96 % of all energy-related greenhouse gas emissions in Germany.

The leading contributor to energy-induced greenhouse gases is the energy industry (public electricity and heating utilities, refineries, the manufacture of solid fuels). The sharp decrease in emissions in this sector between 1990 and 1995 is mainly due to the restructuring processes that took place in the new *Länder*, the accompanying improvement in energy efficiency, the switch to fuels causing lower emissions, and the shutdown of obsolete plants etc. The reductions during subsequent years have been caused by improvements to the efficiency of power plants and other changes to the energy mix, with the increased use of renewable energy or fuels with lower emissions. However, the emissions resulting from energy conversion have risen again in recent years, a consequence of the increased use of lignite for electricity generation purposes, and to a substantial rise in overall electricity generation compared with previous years. However, a comparison of the years from 1990 to 2004 reveals a decline in the greenhouse gas emissions from all sectors, excluding transport.

Development of energy-induced emissions of greenhouse gases in CO_2 equivalents in Germany from 1990 to 2004, according to sectors, in mi. t (excl. diffuse emissions)

	Energy industry	Processing-industries	Transport[1]	Small consumers[2]	Military	Combustion of fossil fuels total
1990	421.6	154.5	164.4	207.9	12.1	960.7
1991	406.4	135.7	168.0	208.1	8.7	926.8
1992	384.5	125.4	173.7	191.1	6.6	881.4
1993	374.7	114.8	178.7	199.7	5.2	873.1
1994	370.6	113.8	175.0	189.3	4.8	853.5
1995	360.6	113.0	178.8	191.8	4.0	848.3
1996	365.9	111.2	178.9	216.8	3.1	875.9
1997	347.9	108.7	179.4	202.5	3.0	841.5
1998	350.6	104.0	182.7	193.9	3.0	834.3
1999	337.5	105.5	188.3	178.0	2.6	811.8
2000	351.3	101.5	184.4	171.9	2.3	811.4
2001	357.1	99.7	180.3	189.7	1.9	828.7
2002	364.5	95.9	178.1	175.6	1.9	816.0
2003	371.1	97.2	172.0	179.3	2.0	821.5
2004	367.8	100.5	172.8	170.2	1.7	812.9

[1] Excl. international aviation
[2] Commercial, public services, households, agriculture and forestry, fisheries

Source: *Federal Environment Agency 2006 (19)*

Objectives and measures for reducing greenhouse gases

As part of the burden-sharing process within the European Union, Germany has given an undertaking to reduce emissions of the six greenhouse gases referred to in the Kyoto Protocol between 2008 and 2012 by 21 % compared with the base year of 1990. A 17.6 % reduction had already been achieved by 2004. However, further efforts will be needed in order to ensure that the international undertakings to attain these objectives can actually be met. Moreover climate protection policy should not cease, either at an international or a national level, in 2012. Medium- and long-term objectives are needed if we are to prevent global warming from exceeding the 2°C increase that has already been recorded since the pre-industrial era. Furthermore the establishment of medium- and long-term objectives also offers investors the necessary planning predictability. The "2°C target" does mean that the industrialized nations will have to achieve an 80 % cut in their emissions by 2050 compared with the starting point in 1990. Germany's intermediate objective should therefore be to attain a 40 % reduction by 2020.

The Federal Government has already stipulated a number of specific targets to reduce emissions of greenhouse gases:

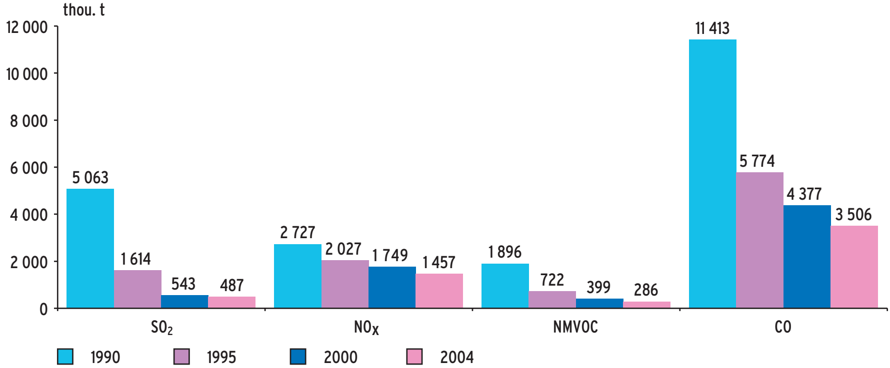
- In its agreement with the Federal Government concerning the reduction in CO_2 emissions and the support for combined heat and power, German industry has given an undertaking to achieve a 45 mi. t. reduction in its CO_2 emissions compared with 2010.
- The retention, modernization and expansion of combined heat and power plants is intended to reduce total annual CO_2 levels from 23 mi. t. to a figure not less than 20 mi. t by 2010 compared with the base year.
- By 2010 renewable energy should account for at least 12.5 % of electricity generation and for 20 % by 2020. By the middle of this century renewable energy is expected to provide half of all energy requirements.
- As a proportion of primary energy consumption, renewable energy should account for 4.2 % of primary energy production by 2010, a doubling of the 2000 level. This target has already been reached.
- Compared with 1990, energy productivity should be doubled by 2020. In order to implement the European emissions trading system the law has stipulated the emissions objectives for the Federal Republic of Germany in § 4 Section 2 of the Allocation Law 2007, and has also required that the objectives for the allocation period 2008 to 2012 should be examined in 2006.

Measures to reduce greenhouse emissions focus on conserving energy, increasing energy efficiency and expanding the use of renewable energy. For example, in line with the scenario in the article on "Primary energy consumption according to energy sources", with improved energy efficiency and the expansion of renewable energy, CO_2 emissions should be reduced by a factor of more than 4 in order to meet 43 % of primary energy consumption by 2050.

Private households and transport are at the centre of the National Climate Protection Programme 2005, because the objectives for industry and the energy sector are being met through emissions trading. For more details see the publication: *"Die Zukunft in unseren Händen – 21 Thesen zur Klimaschutzpolitik des 21. Jahrhunderts"* [9].

Development of energy-induced emissions of airborne pollutants

Emissions of atmospheric pollutants



Source: *Federal Environment Agency 2005 (20)*

Sulphur dioxide (SO_2), nitrous oxide (NO_x), carbon monoxide (CO) and volatile organic compounds (excluding methane, NMVOC) are regarded as the main airborne pollutants.

The individual pollutants are derived from the following:

- NO_x: especially in road traffic (approx. 50 %), electricity and heat generation
- CO: especially in road traffic (approx. 50 %), households, iron/steel industry
- NMVOC: especially in road traffic
- SO_2: especially in electricity and heat generation

There was a sharp fall in emissions of the above-mentioned “traditional” airborne pollutants between 1990 and 2004. This was especially pronounced in the case of emissions of sulphur dioxide (SO_2), which decreased by 90.4 %. Nitrous oxide emissions (NO_x) declined by 46.6 %. The emissions of volatile organic compounds (NMVOC) fell by 84.9 %, and those of carbon monoxide by 69.3 %.

The reduction in airborne pollutants can be attributed to restructuring processes and the impact of EU and German federal law in the new *Länder*. In particular these took the form of the shutdown of many older power stations, measures to improve remaining power stations through the installation of flue gas scrubbers and improvements in electrical efficiency, as well as the construction of new, highly efficient, low emission power stations. A significant factor was also the far-reaching changes in the transport sector, where statutory exhaust regulations led to technical measures (such as modern engine design concepts, replacement of two-stroke engines) and helped to substantially reduce NO_x, CO and NMVOC emissions.

Use of renewable sources

Proportions of the consumption of primary and final energy

Renewable energy (RE) as a proportion in each case of total consumption of primary energy in % (in accordance with efficiency method)

	1998	1999	2000	2001	2002	2003	2004	2005
Electricity generation	0.8	0.9	1.1	1.1	1.4	1.6	1.8	2
Supply of heating	1.3	1.3	1.4	1.4	1.5	1.9	1.9	2
Fuel consumption	0.03	0.03	0.06	0.1	0.1	0.2	0.3	0.6
RE as proportion of total PEC	**2.2**	**2.3**	**2.6**	**2.7**	**3.0**	**3.6**	**4.0**	**4.6**

Renewable energy (RE) as a proportion of final energy consumption (EEC) in %

	1998	1999	2000	2001	2002	2003	2004[4)]	2005[4)]
Electricity generation[1)]	4.8	5.5	6.3	6.7	7.8	8.1	9.5	10.2
Supply of heating[2)]	3.5	3.5	3.9	3.8	3.9	4.9	5.1	5.3
Fuel consumption[3)]	0.2	0.2	0.4	0.6	0.9	1.4	1.9	3.6
RE as proportion of tot. EEC	**3.1**	**3.3**	**3.8**	**3.8**	**4.3**	**5.1**	**5.7**	**6.4**

1) With reference to total gross electricity consumption
2) With reference to total supply of heating
3) With reference to fuel consumption by road vehicles
4) Reference year for heat 2003

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

There are differences in the proportions of renewable energy depending on the reference quantity, i.e. the primary or final energy sector. Primary energy consumption is defined as the sum total of the final energy consumption, non-energy consumption and the conversion balance (conversion input minus the conversion output). Final energy consumption serves directly for the production of useful energy – e.g. for heating rooms, lighting, transport – for the benefit of end users (industry, transport, small consumers).

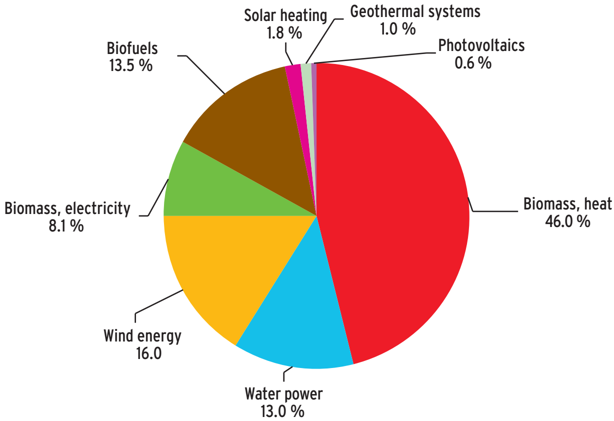
Renewable energy has displayed an upward trend over the past ten years. In 2005 its share of the total consumption of primary energy amounted to 4.6 % (according to the efficiency rate method), consisting of the proportion used for electricity generation (2.0 %), heat generation (2.0 %) and fuel consumption (0.6 %).

In terms of final energy consumption, in 2005 renewable energy contributed a 10.2 % share to electricity generation, 5.3 % to the supply of heating and 3.6 % to transport fuel consumption.

It is foreseeable that the positive trend will continue, supported by the Amendment to the Renewable Energy Sources Act (EEG) and the Marketing Incentive Programme (MAP), to which additions have been made in recent years, and which offer improved conditions for the commercial introduction of and remuneration for renewable energy on the electricity and heating market.

Supply of energy derived from renewable energy sources, and objectives

Supply of energy from renewable energy sources in 2005



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

The supply of electricity, heating and fuels from renewable energy increased considerably from 75.9 TWh in 1997 to 165.4 TWh in 2005. Biomass (mainly wood) accounts for 94 % of the heat generation provided by renewable energy. The main contributors to electricity generation from renewable energy were wind power with 42 % and water power with 35 %.

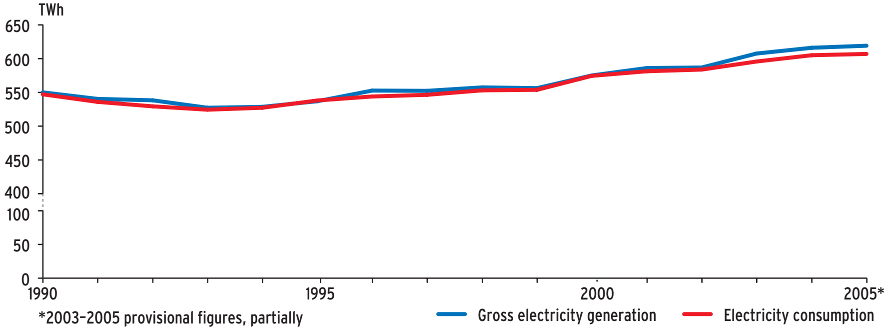
Objectives, instruments and measures for encouraging the use of renewable energy

Germany and the EU have set out some concrete objectives for the development of renewable energy sources. For example the EU aims to increase the contribution made by renewable energy to total electricity consumption within the community to 22 % by 2010. The intention of the German government is to achieve 12.5 % of the country's electricity production using renewable energy by 2010. The amendment of 21.07.2004 to the Renewable Energy Source Act (EEG) states that the purpose of the law is to ensure that at least 20 % of total electricity generation is provided by renewable energy by 2020.

The German government is promoting renewable energy within the scope of research and development and various market incentives. The EEG law imposes a requirement on the operators of electricity networks to give priority to the connection of renewable energy installations without delay, to give priority to the use and transmission of the electricity that they generate, for which they should pay the minimum remuneration. Furthermore the federal and state authorities have set up various programmes to encourage investment in renewable energy. In the coalition agreement of 11.11.2005 the German government specified that the market incentive programme should be augmented by improved assistance.

Gross electricity generation in total and electricity consumption according to sectors

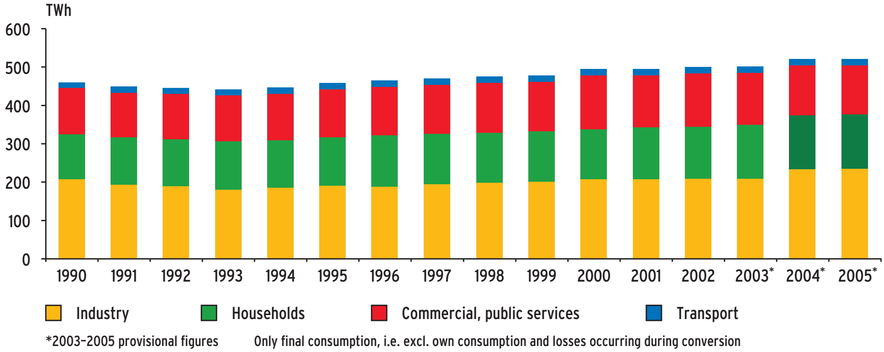
Development of gross electricity generation (including power fed into the public supply by third parties) in Germany



Source: *Working Group on Energy Balances 2006 (22)*

Between 1990 and 2005 gross electricity generation in Germany rose by 12.6 %, despite a fall in 1993 as a result of reunification, when many, mainly obsolete industrial and power plants in the new *Länder* were closed down, initially leading to a decline in electricity generation and consumption. After that date however, in the face of rising demand, electricity generation increased again. Imports and exports within the Union for the Coordination of Transmission of Electricity are used to balance out any discrepancies between electricity consumption and generation.

Electricity consumption in Germany according to sectors

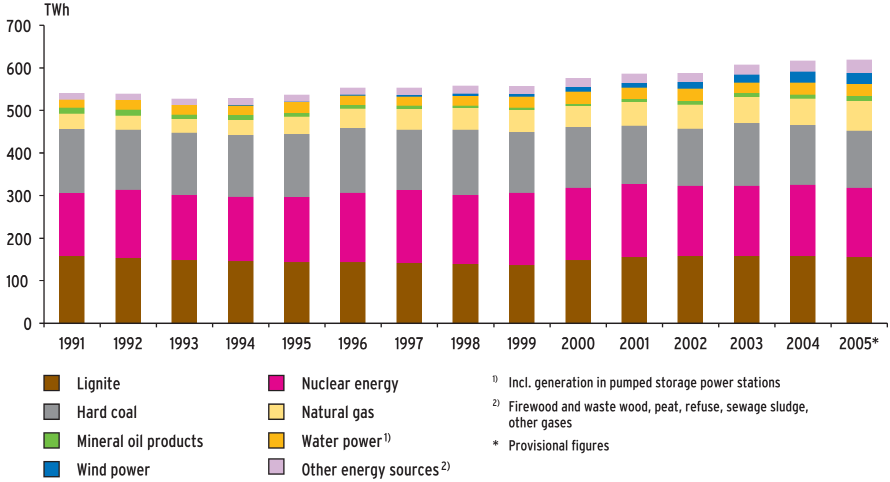


Source: *Working Group on Energy Balances 2006 (15)*

Since the mid-1990s gross electricity generation has been influenced above all by the average rise in electricity consumption by households and German industry. Within this period there was a disproportionately large increase in particular in demand by households, compared with other sectors (+ 21 %), followed by industry (+ 13 %).

Gross electricity generation according to energy sources

Gross electricity generation in Germany by energy sources

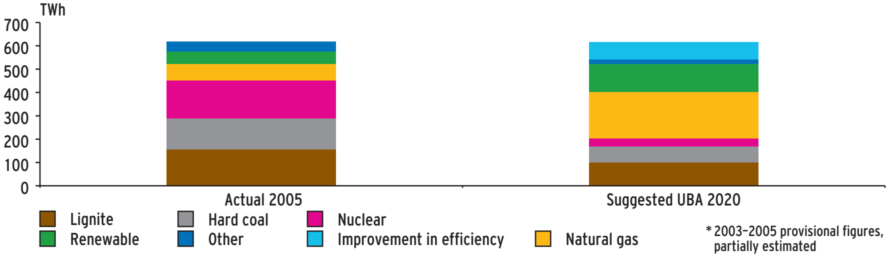


Source: *Working Group on Energy Balances 2006 (22)*

Between 1991 and 2005 there was a significant change in the structure of gross electricity generation, when we consider the various energy sources that were used. From 1991 until 1999 there was a 16 % decline in the use of lignite for generating electricity, followed by a slight rise again, by 12 %, until 2005 (1991 to 2005: −2.1 %). There were fluctuations in the use of hard coal for electricity generation after 1991, but no definite trend can be identified. In 2005 the use of hard coal was just under 12 % less than the figure for 2001. From 1991 until 2000 there was a decline in the use of heating oil (by 65 %), but this figure had doubled by 2005 compared with 2000. The amount of natural gas used for generating electricity almost doubled between 2001 and 2005. During the same period there was an increase of almost 10 % in the amount of electricity generated by nuclear energy. Meanwhile the contribution by renewable energy (water and wind power, biomass, the biogenic contribution from waste, photovoltaics, geothermal installations) has more than trebled: In 1991 renewable energy accounted for 3.2 % of gross electricity generation, compared with 10.2 % by 2005 [10]. For example the amount of electricity generated by wind power has multiplied many times over since 1991.

While the relative contribution to gross electricity generation by lignite, hard coal and heating oil fell between 1990 and 2005, natural gas, water and wind power all acquired growing importance. Accordingly in 2005 the following contributions were made to gross electricity generation: lignite 25 %, nuclear energy 26.3 %, hard coal 21.6 %, natural gas 11.3 %, mineral oil products 1.9 %, water/wind power 8.8 % and the other energy sources (renewable and non-renewable) 5 %. In 2005 coal still made the largest contribution to electricity generation in Germany, with 48 %, but its share had been falling sharply since 1991 (1991: 57 %).

Electricity generation according to energy sources in German power generation system



Source: *Working Group on Energy Balances 2006 (23)*

Calculations by the Federal Environment Agency have shown that the abandonment of nuclear power has been offset by the increase use of renewable energy and by improved efficiency.

By 2020 a more efficient use of energy will be able to enable electricity consumption in Germany, which is currently on the rise, to be reduced by more than 12 % compared with the 2005 level. Numerous technical and organizational solutions exist today which could enable electricity consumption to be reduced significantly, providing the same degree of utilization and in many cases at the same or a reduced cost. The most important measures are the use of more economical electrical appliances, efforts to ensure that equipment in the home, industry, commerce and the service sector is not left on standby, and more economical cross-disciplinary technology, such as more efficient electrical motors and compressed air systems. In future we can expect the continual development and commercial availability of new energy-saving processes too. One good example of this is the use of information technology for the intelligent and energy-efficient control of power engineering processes.

The contribution made by renewable energy could increase to produce at least 110 TWh, which is 20 % of all German electricity generation. There are a number of different scenarios involving calculations that show how renewable energy systems could make an even greater contribution by 2020, one example being a share of just under 25 % of gross electricity generation (excluding biomass, with imports) [11]. The distribution of individual energy sources, with reference to total generation, is as follows: running water (4.7 %), on- & offshore wind (17.3 %), photovoltaics (1.3 %), geothermal installations (0.7 %) and imports (0.5 %). Biomass could also contribute to the generation of electricity with a share of at least 5 %.

By contributing 200 TWh to electricity generation natural gas would increase its share from the present figure of 11 % to 37 % by 2020. To avoid the need to import more natural gas than at present other methods should introduced to replace its use in heating, and these could include biomass, solar heating and the renovation of buildings to improve their heat-retaining properties.

Under this scenario and in accordance with legislation, the use of nuclear energy would cease shortly after 2020. Lignite is now only used to provide 100 TWh, and in the case of hard coal, 70 TWh of electricity generation requirements, but with greater efficiency and thus lower levels of CO_2 emission than at the present time.

Specific use of fuels and total degree of utilization in electricity generation

Development of specific fuel use and total efficiency of electricity generation in Germany

	1990	1995	2000	2005
Specific fuel consumption (MJ/kWh)				
Fossil-fuelled power stations	9.8	9.4	9.1	8.7
Total (incl. nuclear power stations, renewable energy)	9.9	9.6	9.3	8.8
Total efficiency (%)				
Fossil-fuelled power stations	36.8	38.1	39.6	41.3
Total (incl. nuclear power stations, renewable energy)	36.5	37.5	38.8	41.1

Source: *Federal Environment Agency 2006 (24)*

Despite the generation of just under 13 % more electricity, between 1990 and 2005 the amount of energy used to produce electricity fell by 1.1 %. The main contributory factor in this development was the replacement of older power plants because, as a rule, newer installations can offer substantially improved electrical efficiency, in other words they can produce more electricity from the same amount of energy. Moreover wind farms and hydro-electric power stations, which are statistically shown to have 100 % energy efficiency, are contributing more electricity. More natural gas power plants are also being built which, in the form of combined cycle gas turbine powered plants, are particularly efficient. Increased electrical efficiency is also a feature of the average fuel efficiency, which has risen from 36.5 % (1990) to around 41 % (2005).

On average the degree of utilization of power plants burning fossil fuels improved from 36.8 % in 1990 to 41.3 % in 2005. Because nuclear energy and renewable energy systems are not assigned any calorific value, by definition the total degree of utilization of nuclear power plants and hydro-electric/wind power is accordingly 33 % and 100 %. These established values do not alter during the period under consideration and are consequently not shown separately here.

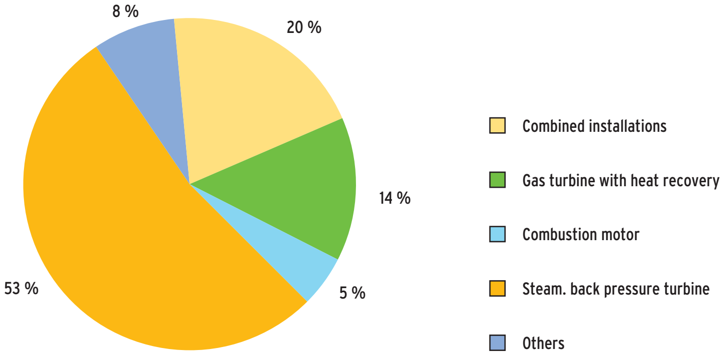
When planning future power plants the best available technology should be used in order to achieve further improvements to the specific fuel consumption and total degree of utilization. Licences should primarily only be granted for power plants if a use for the heat that they produce is assured. Modern technology enables electrical efficiency of up to 45 % in the case of coal-fired power stations and up to 58 % with gas-fired plants to be achieved. These efficiency rates can be improved further through the use of other combustion technologies such as prior coal gasification, enabling higher temperatures to be attained. Over the next 15 years improvements in efficiency of a further 8 percentage points would appear to be a realistic goal. This would correspond to fuel savings of between roughly 15 and 20 % compared with the current available technology (see also *"Die Zukunft in unseren Händen – 21 Thesen zur Klimaschutzpolitik des 21. Jahrhunderts"*) [9].

Generating electricity by means of combined heat and power (CHP)

Combined heat and power (CHP) is an important basis for the more efficient use of primary energy, and thus for attaining climate and energy policy objectives in Germany.

The approval of the Combined Heat and Power Act (KWK-G) in April 2002 has provided an incentive for feeding electricity obtained through the CHP system into the national grid.

Combined heat and power (CHP) electricity generation 2004



Source: *Federal Statistical Office 2006 (25)*

In the period up to 2005 modernization projects in the general supply field, the enlargement of small CHP plants to provide up to 2 MW, and CHP projects in the industrial sector provided additional power generation using the CHP system. Because the assistance schemes expired in 2006 no further expansion of CHP can be expected. This makes amendments to the CHP Act all the more vital.

Several investigations have revealed that a significant increase in electricity generation is possible using CHP. According to a study conducted by the Commission of Enquiry of the 14th session of the Deutscher Bundestag (lower house of parliament) into "Sustainable Energy Supplies", CHP could make a substantial contribution to reducing greenhouse gas emissions by 80 % between now and the middle of the century [12]. In the conversion efficiency scenario of the study by the Commission of Enquiry, by 2020 CHP would account for well over a quarter of electricity production. In absolute terms this would mean annual production of 140 TWh of electricity using CHP by 2020 and almost 260 TWh by 2050. With the greater use of biomass increased efforts should be made to utilize it in CHP systems.

The use of renewable energy to generate electricity

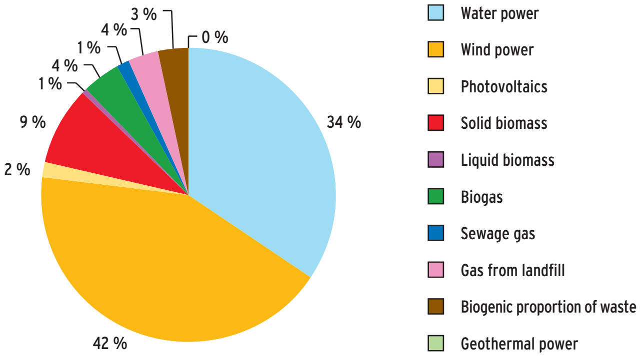
Between 1998 and 2005 renewable energy increased its share of gross electricity consumption from 4.8 to 10.2 %, while the proportion of total primary energy consumption that was produced using electricity generated from renewable energy sources rose from 0.8 to 2 % over the same period.

In view of the dynamic growth of recent years the German government's expansion target should be easily attainable: as part of the National Sustainability Strategy 2002 and the amended Renewable Energy Source Act (EEG) of 21.7.2004, it was agreed to increase the amount of electricity generated in Germany using renewable energy to a minimum of 12.5 % by 2010 at least 20 % by 2020.

In recent years a major contribution to the increase in the electricity generated using renewable energy has come from wind power in particular, with a rise in the installed capacity from 56 MW in 1990 to 18 428 MW in 2005. As a result there has been an expansion in the amount of electricity generated using wind power, from 40 GWh in 1990 to 26 500 GWh in 2005, and by 2000 it had superseded hydroelectric power as the single most important renewable energy source for the production of electricity. Depending on the amount of available wind a modern wind farm in Germany with a generating output of 1.5 MW can produce an average of 3 mi. kWh of electricity, which is equivalent to the average amount consumed by 850 households.

In 2005 the electricity utilities and private sector plant operators generated some 62.5 TWh of electricity using water and wind power, biomass, solar energy (photovoltaics) and geothermal systems.

Proportion of electricity generated from renewable sources in Germany 2005 (62 468 GWh)



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

Despite an increase in the amount of electricity being supplied by renewable energy, in absolute terms the increase in gross electricity consumption since 1990 has exceeded that of renewable energy. This situation will be reversed over the next few years if renewable energy continues to increase its share of gross electricity consumption at its present rate, provided that there is no sharper rise in gross electricity consumption. In fact, efforts should be made to reduce gross electricity consumption by exploiting the potential for improved efficiency, in order to attain the long term objective of sustainable energy supplies and to reduce dependency on fossil sources of energy.

Amount of fossil fuels saved by using renewable energy to generate electricity in 2005

	Lignite	Hard coal	Natural gas	Heating oil	Diesel	Petrol	Total
			Primary energy (PJ)				
Electricity	317.2	244.4	38.6	–	–	–	600.1

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

The use of renewable energy sources to generate electricity will enable fossil energy sources to be replaced. We can expect lignite-fired, constant load power stations to be replaced by hydroelectric generating stations, while wind power will mainly be used in place of middle load power stations (hard coal and natural gas) for generating electricity [13].

A total of 600.1 PJ of fossil-based primary energy was saved in 2005.

Avoidance of CO_2 emissions through the use of renewable energy to generate electricity in 2005

	Generation/provision from RE (TWh)	Emission factor (kg/GWh)	Emissions avoided (thou. t)
Electricity generation[1)]	62 468	929 147	58 042

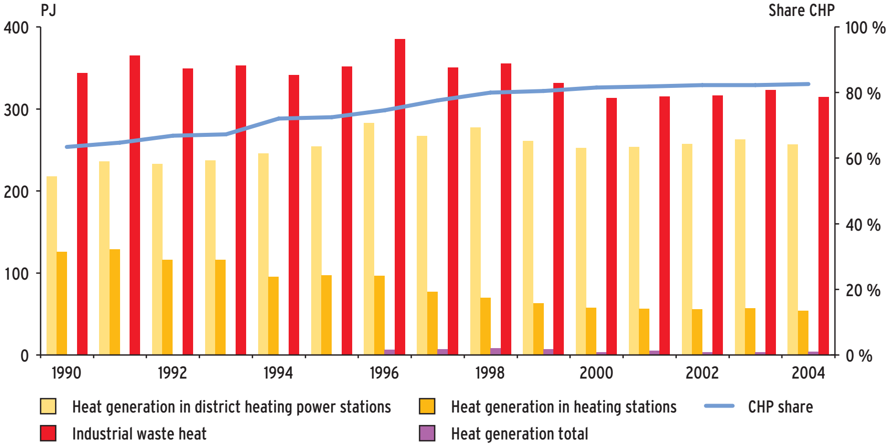
1) Electricity generated using wind, biomass, solar energy and geothermal energy

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

In 2005 the use of renewable energy to generate electricity avoided the emission of some 58 mi. t. of CO_2. Including methane (CH_4) and nitrous oxide (N_2O), the reduction over the same period amounted to 58.7 mi. t of CO_2 equivalents. This corresponds to a 7.2 % share of total, energy-induced emissions of greenhouse gases (excluding diffuse emissions).

Generating heat by means of combined heat and power (CHP)

District heating generation – heating fed into the public supply by district heating power stations and heating stations[1)]

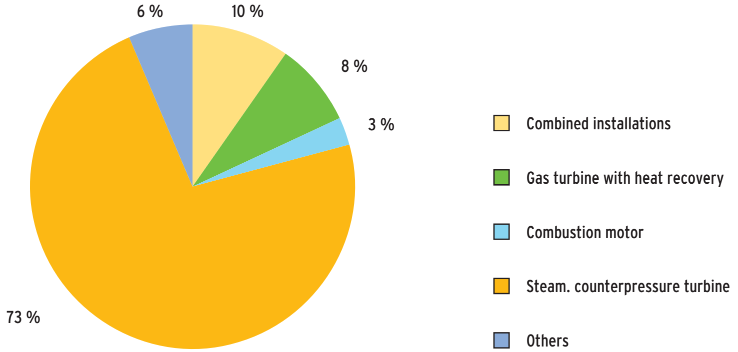


1) Methodological break in the distribution of district heating generation in district heating power stations and heating stations 1995/1996.

Source: *German Heat and Power Association 2005*

Between 1990 and 2004 the contribution made by combined heat and power to heat generation increased from 63 to 83 %. These details only cover those district heating supply companies that have furnished data for the respective German Heat and Power Association Main Report on District Heating Supplies. The German Heat and Power Association estimates that some 86 % are represented here.

Heat generation 2004 by combined heat and power for general supply purposes



Source: *Federal Statistical Office 2006 (25)*

In 2004 steam turbines were used to provide 73 % of the heat that was generated by means of combined heat and power for general supply purposes.

Use of renewable energy to generate heat

Renewable energy (RE) as a proportion of total heat provided, in %

	1998	1999	2000	2001	2002	2003	2004[1)]	2005[1)]
Of heating provided	3.5	3.5	3.9	3.8	3.9	4.9	5.1	5.3
Of primary energy consumption	1.3	1.3	1.4	1.4	1.5	1.9	1.9	2

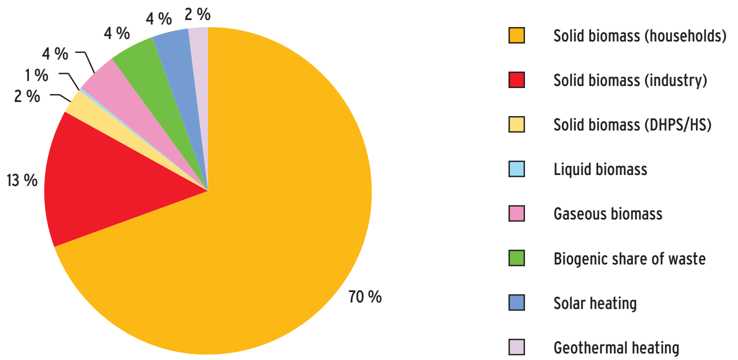
[1)] Reference year 2003

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

The increase in the use of renewable energy to generate heat in recent years is mainly due to the market incentive programme, which has encouraged the use of biomass, solar and geothermal solar power to generate heating. The intensive application of this programme has, however, also caused a reduction in the incentive rates, leading to a downward tendency in the number of applications for assistance. The continuing rise in the prices of heating oil and other fossil fuels during 2005 contributed to a further increase in the use of renewable energy sources for the supply of heating.

In 2005 renewable energy was used to provide 80.6 TWh of heating, with biomass accounting for the largest proportion, 76 TWh, compared with 3 TWh and 1.6 TWh respectively from solar and geothermal energy. Overall renewable energy accounted for 5.3 % of all the heating provided.

Proportion of heating provided by renewable energy in Germany 2005



Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

Fossil energy sources savings through use of renewable energy for heat generation in 2005

	Lignite	Hard coal	Natural gas	Heating oil	Diesel	Petrol	Total
	Primary energy (PJ)						
Heating	6.1	1.4	165.2	133.6	–	–	306.7

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

The use of renewable energy sources to generate heat allows fossil energy sources to be replaced in significant quantities. In calculating the quantitative savings of fossil fuels it is assumed that natural gas and heating oil in particular are replaced, which are mainly used by small consumers (private households, industry, commerce and the service sector). Lignite and hard coal tend to be less widely used in this particular context.

Where renewable energy is used to provide heating it is assumed that this mainly involves wood-fired heating systems. For every kilowatt hour of energy from renewable sources the saving on fossil fuels is 4.0 MJ compared with oil-fired heating systems, and 3.9 MJ compared with gas-fired systems. For the various forms of coal-fired heating the figures are 5.7 MJ (coal briquettes), 6.5 MJ (lignite briquettes) and 7.3 MJ (coke obtained from hard coal). Determining which fuel is replaced, and to what extent, reveals the structure of the mix used to provide heating: natural gas (52.9 %), heating oil (41.5 %), coal (1.5 %) and electricity (4.1 %). Altogether 306.7 PJ of fossil primary energy is saved in the supply of heating.

Avoidance of CO_2 emissions through use of renewable energy to generate heat in 2005

	Generation/provision using RE (TWh)	Emission factor (kg/GWh)	Emissions avoided (Tsd. t)
Provision of heating[1)]	80 560	228 555	18 412

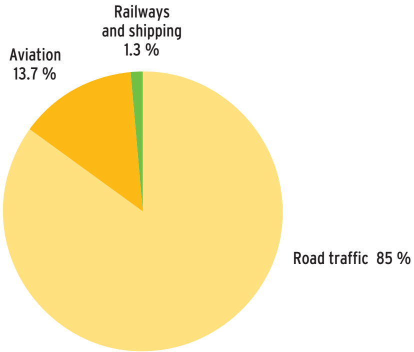
[1)] Provision of heating from biomass, solar heating and geothermal heating

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2006 (21)*

In 2005 the use of renewable energy to provide heating avoided the emission of 18.4 mi. t. of CO_2. Including methane (CH_4) and nitrous oxide (N_2O), the reduction over the same period amounted to 18.5 mi. t of CO_2 equivalents. This corresponds to a 2.3 % share of total, energy-induced emissions of greenhouse gases (excluding diffuse emissions).

Fossil and alternative fuels

Fuel consumption in Germany according to forms of transport (reference year 2005)



Source: *Federal Environment Agency 2006 (26)*

The consumption of end energy required for the provision of transport services rose by just under 17% from 2 379 PJ in 1990 to 2 781 PJ in 1999, and since then it has declined again slightly, in particular due to the sharp rise in the cost of fuel. In 2005 end energy consumption in the transport sector amounted to 2 628 PJ, which is 28.7 % of total end energy consumption in Germany. This is a 3.6 percentage points increase over 1990.

Approximately 95 % of the energy consumed in the transport sector is accounted for by fuel. With the exception of rail transport, where electricity supplies over 80 % of all the power requirements, fuels are the dominant energy sources.

In terms of the energy content, a breakdown of consumption reveals that 40 % is accounted for by petrol, 46 % by diesel fuel and 14 % by jet aviation fuel/avgas.

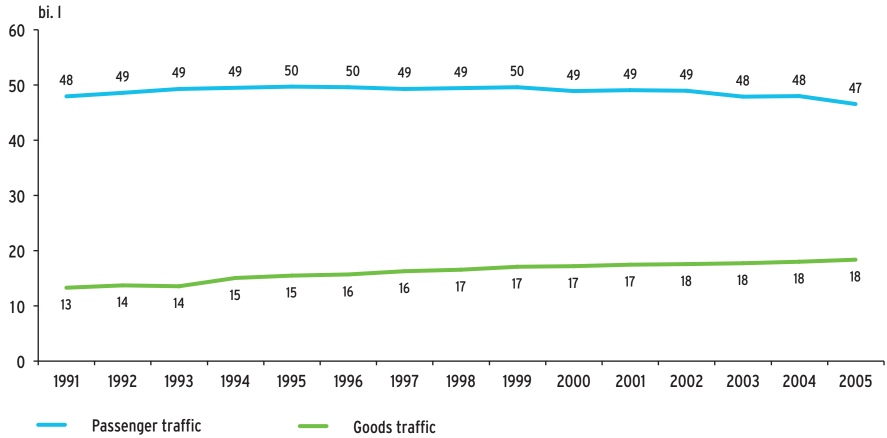
The largest proportion of fuel, 85 %, is used in road transport, with the remainder being accounted for by aviation and, to a much lesser extent, by the railways and inland shipping.

Increasing amounts of biogenic fuels (biodiesel, vegetable oil, bioethanol) have been used on the roads since 1999. In 2005 their share of all the fuel used for road traffic was already 3.6 %. The replacement of conventional fuels by biofuels enables reductions to be made in emissions of those gases which are harmful for the climate. However, the reduction in emissions per hectare of cultivated biomass only amounts to about 1/3 to 1/7 of the reductions achieved when biomass is used in stationary installations (for generating electricity, heat).

Moreover the specific cost of reducing climate gas emissions using the biofuels that are currently available is very high, at 250 EUR/t CO_2 equivalent.

Fuel consumption in road passenger and freight transport

Fuel consumption by road traffic



Source: *Federal Environment Agency 2006 (26)*

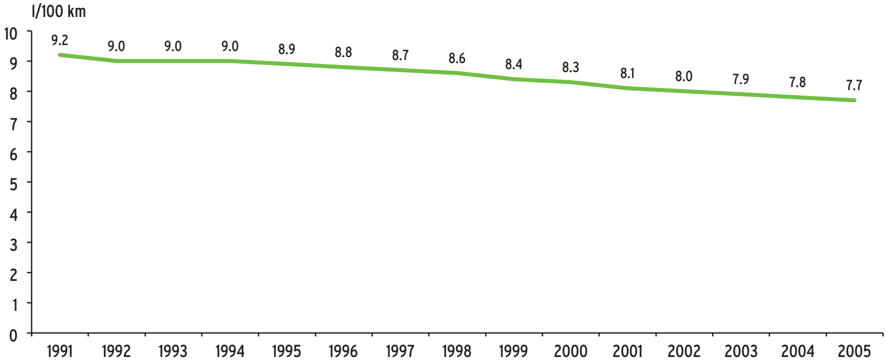
In 2005 the amount of fuel consumed by road transport in Germany was approximately 3.7 bi. l more than the 1991 figure, a rise of some 6 %. The increase in consumption by passenger transport varied from that of the freight sector.

Passenger transport in 2005 recorded 2.9 % less consumption than in 1991, due to a number of factors: a substantial rise in fuel costs, improvements to the public transport system and a reduction in the specific fuel consumption of private cars (see article on “Specific fuel consumption”).

In contrast the fuel consumption by the road freight sector rose by 38.2 % between 1991 and 2005, a consequence of a considerable increase in the volume of transport, which more than outweighed any technical improvements in fuel consumption. Freight transport’s share of the amount of fuel used on the roads grew from 22 % in 1991 to 28 % in 2005.

Specific fuel consumption

Average fuel consumption by cars/estate cars per 100 km



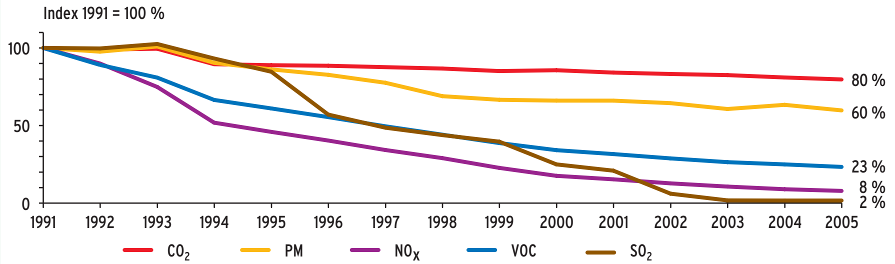
Source: *Federal Environment Agency 2006 (26)*

Since 1991 there has been an annual decrease of 0.1 l per 100 km in the average fuel consumption of private cars. Throughout the entire period from 1991 to 2005 average consumption fell by just under 1.5 l per 100 km, due primarily to ongoing improvements in automotive technology, such as more economical engines and vehicle design and, especially since 1999, an increase in the number of diesel-powered vehicles, which, with comparable vehicle parameters, can achieve lower consumption.

Contrasting with the greater reduction in fuel consumption there has been a trend for more powerful, heavier vehicles and the installation of more ancillary equipment and comfort features such as air conditioning, which also increase consumption.

Specific pollutant emissions of transport

Specific emissions by cars (emissions by cars / transport volume by cars)



Source: *Federal Environment Agency 2006 (26)*

Motorized individual transport

Specific emissions per passenger kilometre have fallen in all sectors since 1991. Considerable reductions in SO_2 to 2 % or in VOC to 8 % contrast with a much smaller decline in CO_2 levels to 80 %. This is a consequence of the technical improvements that have been introduced following the gradual imposition of stricter regulations governing exhaust emissions by new cars, the retrofitting of catalysts to older cars and improved fuel quality.

However, when we consider total emissions by passenger cars it is evident that the reductions in emissions per passenger kilometre resulting from technical improvements have been almost completely cancelled out, in the case of CO_2, or partially, for other pollutants, by a general increase in the transport volume. For example, the decline in total emissions of fine dust produced by cars since 1991 was only 27 %, due to the 144 % increase in transport volume for diesel-engined cars since 1991.

This means that the problems presented by transport cannot be solved simply by introducing technical refinements, but must be addressed in combination with other measures such as greater vehicle efficiency and an improvement in the modal split, i.e. a proportionate increase in low emission forms of transport compared with transport volume as a whole.

Road freight transport

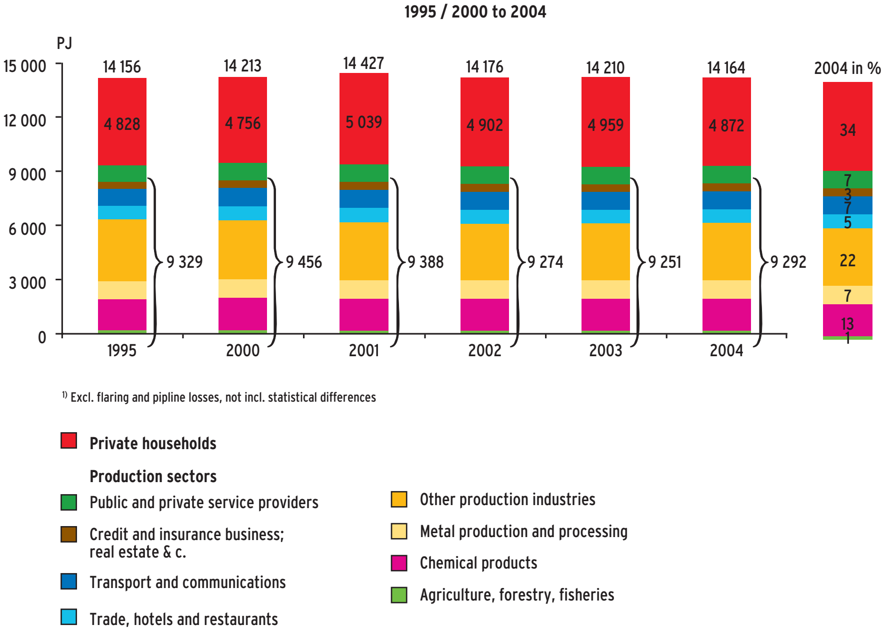
In almost all areas of road freight transport too the specific emissions per transport volume (tonne/kilometre) compared with 1991 have fallen as a result of advances in automotive technology and improved fuel quality. Considerable reductions in SO_2 to less than 1 % contrast with a much smaller decline in CO_2 levels to 77 %.

Turning to total emissions by road freight transport it is evident that, as in passenger transport (with the exception of SO_2 emissions), the reductions per tonne/kilometre produced by technical improvements have been cancelled out by substantial increases in transport volume (160 % compared with 1991), either partially, (particles and VOC) or almost completely (NO_x), and in the case of CO_2 these reductions have actually been outweighed. Despite all the technical improvements that have been made, in 2005 the total CO_2 emissions from road freight transport were 123 % higher than in 1991.

PRODUCTION AND CONSUMPTION: MAKING EFFICIENT AND SUSTAINABLE USE OF RESOURCES

Energy consumption (total, absolute and proportional)

Consumption of primary energy according to economic activities[1)]



Source: *Federal Statistical Office 2006 (6)*

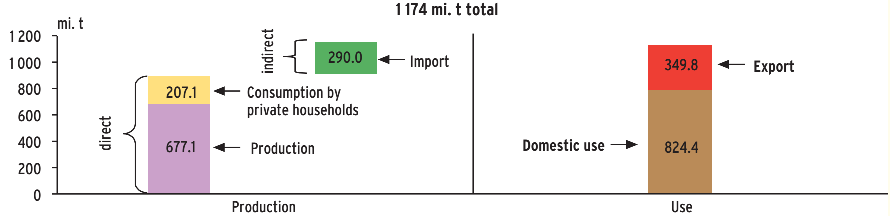
Energy consumption by the production sectors is shown using the consumption of primary energy. In addition to the consumption of end energy, the primary consumption of energy by production sectors includes the consumption of energy carriers for non-energy purposes, consumption by conversion sectors for own purposes and the proportionate losses resulting from the conversion of energy carriers (losses incurred in the generation of electricity and district heating).

By 2004, following a slight rise of 127 PJ, or 1.4 %, between 1995 and 2000, primary energy consumption by production sectors had fallen back to the 1995 level. As had already occurred in 1995, the production sectors' share of total primary energy consumption in 2004 was approximately 66 %. With 42 %, manufacturing sector accounted for the largest share among production sectors, followed by public and private sector service providers (7 %) and commerce and the catering and hotel sector (7 %).

These shares of consumption remained relatively constant between 1995 and 2004. Manufacturing sector as a whole displayed a slight decline from 43.2 % (1995) to 42.0 % (2004), whereas the share accounted for by transport and communication increased slightly, from 6.7 % (1995) to 7.2 % (2004), as did the proportion accounted for by public and private sector service providers, from 6.5 % (1995) to 6.9 % (2005).

Accumulated domestic CO_2-emissions including intermediate inputs

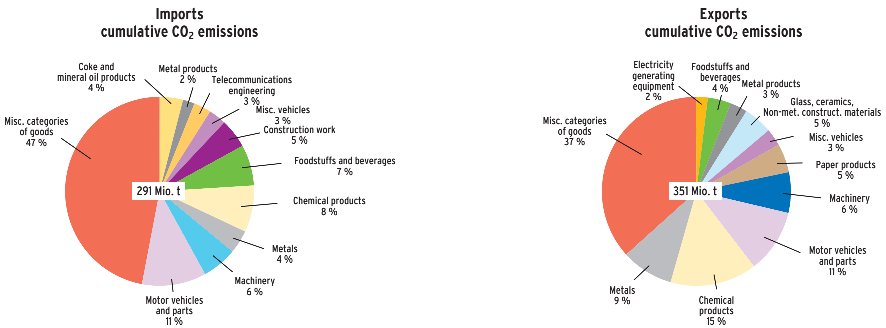
Production and use of CO_2 emissions 2003



Source: *Federal Statistical Office 2006 (6)*

The diagram shows the production and use side of domestic CO_2 emissions. The production side differentiates between those emissions created as a result of domestic production and those arising from private consumption (primarily from the use of thermal energy). Furthermore the emissions associated with imported goods (where the emissions occur abroad) are included under the amount produced. This amount therefore includes all CO_2 emissions resulting from production (domestic production and, in the case of imported goods, the proportion occurring abroad) and from domestic consumption. The amount of emissions that occur can be broken down in terms of use into exports and domestic use, the latter being derived from consumption by private households and by the state, and from fixed asset investments.

CO_2 emissions from imports and exports, according to product groups



Source: *Federal Statistical Office 2006 (6)*

Among imports the biggest contribution to CO_2 emissions is made by the following groups: “motor vehicles and motor vehicle parts” (11 %), “chemical products” (8 %), “foodstuffs and beverages” (7 %), “machinery” (6 %) and “construction work” (5 %). Together they account for 37 %. The significant groups among exports are “chemical products” (15 %), “motor vehicles and motor vehicle parts” (11 %), “metals” (9 %), “machinery” (7 %) and “paper products” (5 %), which are responsible for just under half of all CO_2 emissions (47 %). This comparison clearly shows that import emissions are spread more strongly over product areas, whereas, in the case of exports, a greater concentration is apparent.

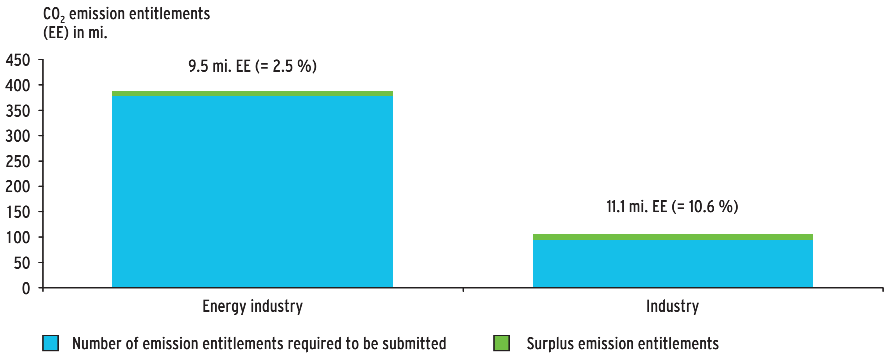
Efficient climate protection through emissions trading

On 1 January 2005 the European Union introduced emissions trading in CO_2 for certain industries in its member states.

In Germany in 2005 the German Emissions Trading Agency (DEHSt) provided plant operators with a "starting balance" of legally based emissions entitlements, free of charge. During the first allocation period (2005 to 2007) plant operators are granted an annual budget of 495 mi. t. of CO_2. If a company's actual CO_2 emissions are below the allocated emissions entitlement, the surplus can be sold on the open market. Conversely it can purchase emissions entitlements on the market if its actual CO_2 emissions exceed the amount in its entitlement and if its own measures to reduce emissions would be more expensive.

Large energy installations and industrial plants with high emission levels participate in emissions trading. They represent around 55 % of all the CO_2 emissions produced annually in Germany. With two thirds of its plants and just under 80 % of all emissions entitlements the energy industry is the largest participant in emissions trading in Germany. Emission-intensive industries accounted for one third of all plants and over 20 % of the entitlements issued. In 2005 emissions of CO_2 in Germany totalled just under 474 mi. t. This is around 4 % or 21 mi. t less than the amount covered by the emissions entitlements issued in 2005.

Surplus CO_2 emission entitlements (EE) – comparison between energy industry and industry



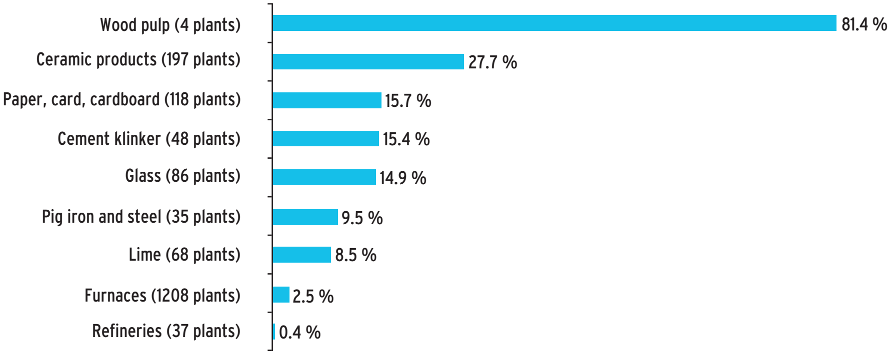
Source: *Federal Environment Agency 2006 (27)*

Evaluations by the DEHSt reveal that climate protection measures resulted in a 9 mi. t reduction in CO_2 emissions in real terms in 2005 by the companies required to conduct emissions trading – measured according to the average for the base periods between 2000 and 2002 [14]. Additional emission entitlements amounting to 12 mi. t. were distributed among the participating sectors of industry as a result of special arrangements that came into force with the Allocation Law (ZuG 2007 of 31.8.2004).

In absolute terms in 2005 surplus emissions entitlements were distributed between the energy industry (plus 9.5 mi. t of emissions entitlements) and industries with high levels of emissions (plus 11.1 mi. t of emissions entitlements). Because of its small share of the budget for emissions entitlements the relative surplus of those industries with high emission levels turns out to be much higher.

Plants in the wood pulp industry produced the largest surplus, followed by those engaged in the manufacture of “ceramic products”. A slight surplus was achieved by furnaces in the energy industry and refineries.

Extent of the surplus above the allocated quantity, and number of plants per sector

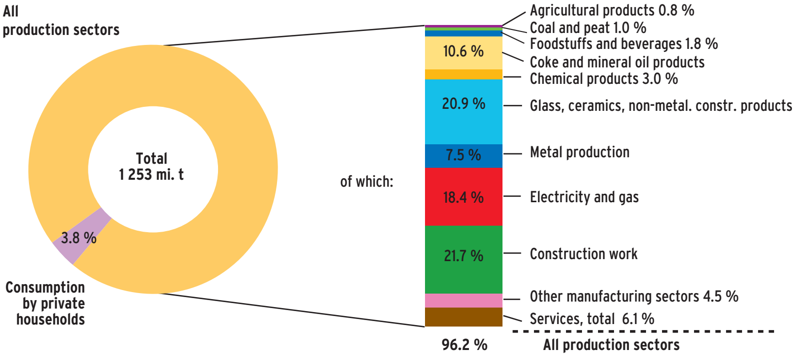


Source: *Federal Environment Agency 2006 (27)*

At the end of the first trading period, from 2005 to 2007, all emissions entitlements will be cancelled. For the second trading period, from 2008 to 2012, a total budget of 453.1 million tonnes CO_2 per year is allocated to installations that are subject to the emissions trading system.

Consumption of raw materials according to production sectors

Use of abiotic primary materials according to economic activity 2004



Source: *Federal Statistical Office 2006 (6)*

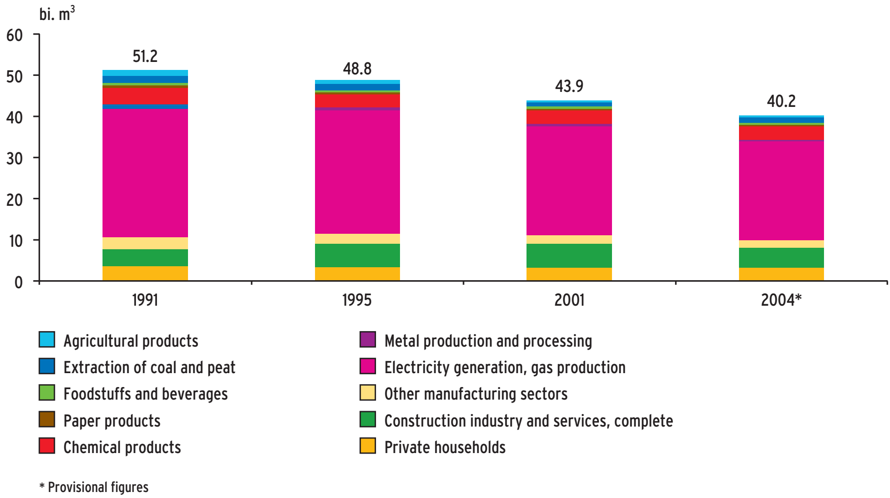
Out of a total amount of primary material used (utilized domestic extraction of abiotic raw materials plus imports of abiotic goods) of 1 337 mi. t in 2004 some 1 253 mi. t. was used as intermediate consumption for production and for direct consumption by private households. The remaining 84 mi. t can be accounted for in particular by exports. Consumption by private households amounted to 3.8 % of the primary material used, a relatively small figure compared with the 96.2 % used by the production sectors.

Of these production sectors in 2004 by far the largest share of primary material (90.9 %) was used by manufacturing sectors, compared with just 5.4 % by service sectors. Among the manufacturing sectors the major users of abiotic raw materials and imported abiotic goods are as follows: “glass, ceramics, non-metallic building materials” (20.9 %), “construction work” (21.7 %), “electricity and gas” (18.4 %) and “metal production” (7.5 %). Together these production sectors account for almost 70 % of all the material used. This strong concentration on just a few sectors is an indication that overall economic development of the use of materials in absolute terms and of “raw material productivity” as an indicator of sustainability is largely determined by the development taking place in these sectors.

Between 1995 and 2004 production sectors recorded an overall decline of 156 mi. t in the use of abiotic material. Over the period under consideration, this development was characterized in particular by a significant decline in the amount of materials used in the sectors of “glass, ceramics, non-metallic building materials” (– 142 mi. t) and “construction work” (– 15 mi. t).There was also a decline in the materials used in the sector of “coal and peat” (– 12 mi. t).

Water consumption according to production sectors

Water use according to production sectors and private households



Source: *Federal Statistical Office 2006 (6)*

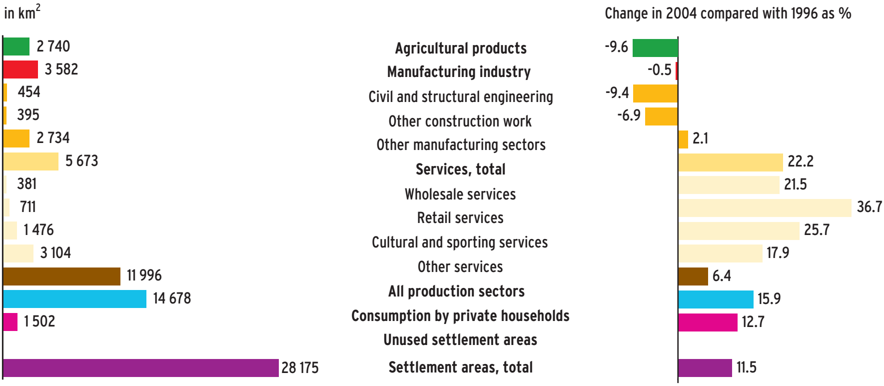
The water used by production sectors and private households comprises the amounts that they abstract themselves together with the quantities obtained from outside suppliers, less the amounts dispensed to other units. According to the concept of Environmental Economic Accounting, total water use also includes foreign water and rainwater, losses, and water which is discharged without being used.

Since 1991 there has been a constant decrease in the amount of water used. In 1991 it had a volume of 51.2 bi. m^3, but by 2004 this had declined by 22 % to 40.2 bi. m^3, reflecting the much more efficient way in which water was being used in production sectors and in private households.

Of the total water use of 40.2 bi. m^3 in 2004, 92 % was accounted for by production and the remaining 8 % by private households. Well over half of all domestic water use was in the production area of "generation of electricity and production of gas" (59.6 %), where it was used almost exclusively for cooling purposes. A comparatively large proportion of total water use was also accounted for by the production sectors "manufacture of chemical products" (8.0 %), "extraction of coal and peat" (3.3 %), "production and processing of metals" (1.2 %) and „agricultural products" (1.1 %). Where water is used in the "extraction of coal and peat" this consists almost entirely of unused, discharged water from pits, while irrigation water dominates in the production sector of "agricultural products".

Demands on land area according to economic activities

Settlement area according to economic activity 2004



Source: *Federal Statistical Office 2006 (6)*

The differences between settlement areas according to users (production sectors and private households) in 2004 are as follows: over half (52.1 %) of the total settlement area (14 678 km^2 out of 28 175 km^2) is used by private households. 42.6 % is occupied by various production sectors, and 5.3 % is unused. The latter includes, for example, construction sites, areas containing unused buildings, disused operational areas or undeveloped areas which have been earmarked for the expansion of operating facilities or as locations for new facilities.

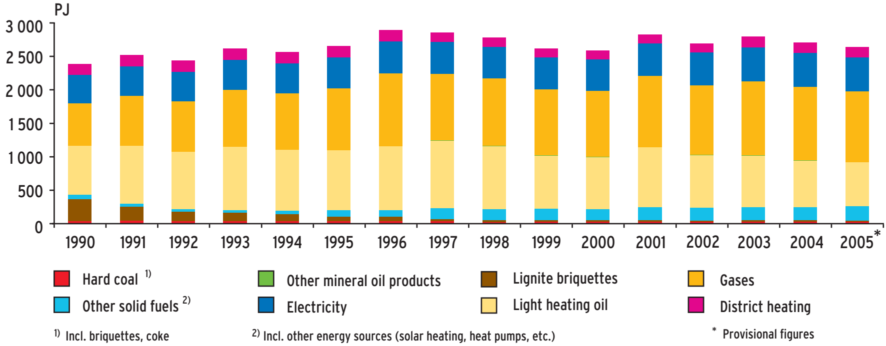
Among production sectors the predominant form of settlement use is for services with 20.1 % compared with 12.7 % for manufacturing sectors and 9.7 % for agricultural products (including products from forestry and fisheries).

If we consider the development of settlement areas between 1996 and 2004 we find that the increase of 15.9 % in the settlement areas used by private households was the main contributory factor, while the expansion in production sectors was less pronounced at 6.4 %.

Among production sectors only that of services, with 22.2 %, revealed an increase in settlement areas. In contrast the settlement areas used for agricultural products and the manufacturing industry declined by 9.6 % and 0.5 % respectively.

Direct energy consumption by households according to energy sources

Development of direct energy consumption by households



Source: *Working Group on Energy Balances 2006 (15)*

The Working Group on Energy Balances refers to the use of energy sources for the purposes of useful energy, e.g. electricity for lighting or gas for cooking, as direct energy consumption by private households. Contrasting with this is so-called indirect energy consumption, meaning the energy which end-users consume indirectly through the goods and services which they obtain, i.e. the energy used in production and distribution.

The direct energy consumption by private households in 2005 was 10.7 % above the level for 1990[1]. Over the past fifteen years the development of this indicator has revealed fluctuations, mainly due to the weather, with a relatively sharp decline between 1996 and 2000. For example, the winters of 1996 and 2001 were very cold, leading to a sharp rise in fuel consumption. It should be remembered that the proportion accounted for by lignite, which was primarily used for heating in the new *Länder* in the early 1990s, has declined sharply. The consumption of light heating oil rose until 1997 but since then has undergone a downward trend, only interrupted in 2001 on account of the weather. This decline has been accompanied by rising prices. On the other hand over the period under consideration gas (especially natural gas) became the most important energy source in this field, with a growth rate of 67 %, accounting for 40 % of all direct energy consumed by private households by 2005. Whereas there were only slight fluctuations in the consumption of electricity and district heating between 1990 and 2005, there has been a constant rise in the consumption of other solid fuels (particularly wood, and recently of increased amounts of wood chips and wood pellets), as well as greater use of other energy sources, including solar power and heat pumps. As a consequence there has been a shift in the mix of energy sources in favour of fuels producing lower CO_2 emissions, and this has led to a reduction in the emissions of greenhouse gases caused directly by households.

[1] Excluding fuel consumption, because this comes under the transport sector.

Final energy consumption by households according to areas of application

Distribution of final energy consumption (FEC) by households according to areas of application in Germany in 2004 in PJ[1)]

	Oil	Gas	Elec.	District heating	Coal	Misc.[2)]	Total	Proportion of FEC (%)
Room heating	712	935	88	147	47	188	2 116	75.8
Hot water	59	149	82	15	3	9	317	11.3
Other process heating	0	18	94	0	0	6	117	4.2
Heating, total	**771**	**1 102**	**264**	**161**	**50**	**202**	**2 550**	**91.4**
Mech. energy	0	0	149	0	0	0	149	5.4
Information/comm.	0	0	50	0	0	0	50	1.8
Lighting	0	0	41	0	0	0	41	1.5
Total	**771**	**1 102**	**504**	**161**	**50**	**202**	**2 793**	**100**

1) In these observations the consumption of the various energy sources is allocated to the respective area of application. As a result the electricity used by refrigerators and freezers comes under "Mechanical Energy". The water heating for electrically powered washing machines and dishwashers is assigned to the hot water sector. Air-conditioning comes under room heating.

2) Renewable energy in particular

Source: *German Electricity Association 2006 (28)*

More than three quarters of the total final energy consumption in private households is used for room heating, the main fuels being natural gas and heating oil. The third most important energy source for household heating is electricity. The use of this high grade form of energy for heating is ecologically and economically unacceptable because conventional power stations themselves are responsible for high losses resulting from heat conversion in the generation of electricity.

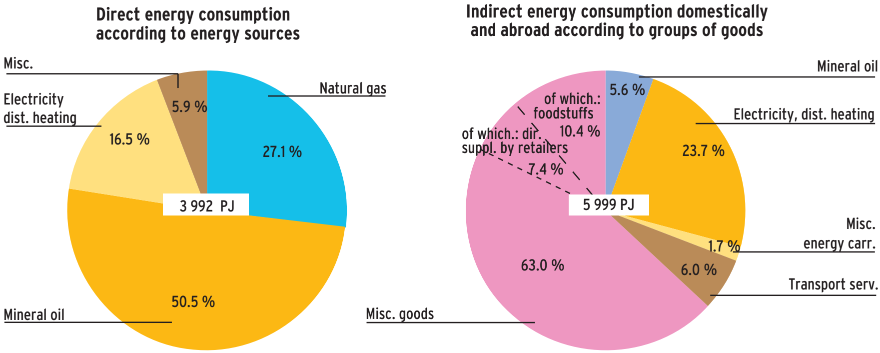
There has been a sharp rise in the consumption of electricity for information and communication purposes, which now exceeds the amount used for lighting.

Heating rooms accounts for by far the largest share of all the final energy use by private households and, if the entire housing stock were to be renovated to improve energy efficiency consumption, this could lead to reductions of almost 60 % (the technical potential). The German Development Bank (KfW) is providing financial assistance for this process with its building renovation programme. Another measure involves the introduction of a demand-oriented energy pass for existing buildings. Other possibilities also exist for reducing the consumption required for heating rooms, including a change in the law on rented property to provide a possibility for increased apportionments for investments intended solely to conserve energy, and a comprehensive and representative picture of local heating costs.

Electricity consumption in private households can be reduced by replacing electric heating by more ecological acceptable heating systems, by utilizing household appliances and lighting that use less electricity, and by the more careful use of electricity.

Energy consumption by households with the inclusion of imported goods

Direct and indirect energy consumption by private households according to groups of goods 2003



Source: *Federal Statistical Office 2006 (6)*

According to the methodological distinction provided by the Environmental Economic Accounting, the entire energy consumption by private households includes the direct use of energy sources and the indirect energy consumption. Direct energy consumption refers to the end energy consumed by households plus the fuel required by the household's own vehicles. Indirect energy consumption contains the energy needed in the manufacture of consumer goods for private households.

In 2003 the direct energy consumption by private households, including vehicle fuel, amounted to 3 992 PJ. This is approx. 40 % of the total energy consumption of 9 991 PJ. Roughly 60 % of the total energy consumed – 5 999 PJ – results from the energy used in the manufacture of consumer goods.

Some 30 % of this indirect energy consumption takes place in connection with the extraction, conversion and distribution of the energy sources that are directly used by households. Considerable amounts of energy are lost in converting energy sources such as coal, which are used in power stations to produce electricity. Thus 1 420 PJ or 23.7 % of indirect energy consumption is accounted for by the proportionate conversion losses incurred during electricity generation and the production of district heating. The provision of natural gas, on the other hand, incurs much lower energy losses, amounting to only about 5 % of the natural gas that is directly used. In terms of energy losses natural gas is therefore a highly efficient source of energy.

Other significant, indirect forms of energy consumption, based on demand, are foodstuffs and public transport, as well as retail services.

Meeting the energy requirements of existing buildings in a sustainable way

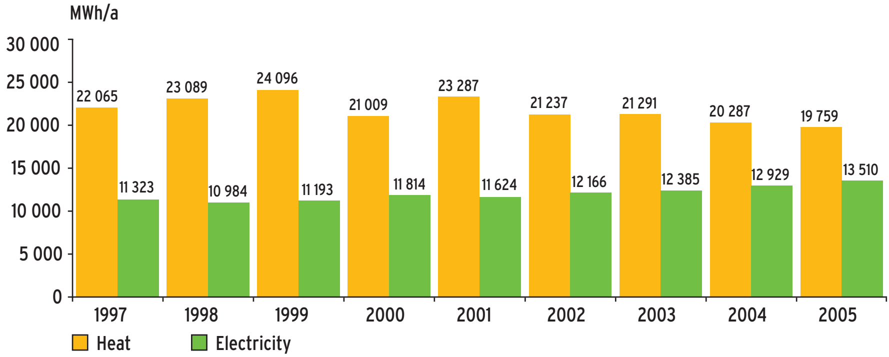
The environmental department's buildings as an example

The German Federal Government has set itself some challenging objectives in its efforts to optimize energy supplies, emphasize its climate policy intentions and set an example. As a more far-reaching objective the environmental department intends to reduce the output of carbon dioxide between 2008 and 2012 by 30 % compared with 1990 levels. It has introduced numerous energy conservation measures in pursuit of this objective. As part of a research project the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) arranged for analyses of the energy efficiency of all the properties that come within its scope, and obtained information about possible course of action to conserve energy. The various measures were assessed in terms of their efficiency and ecological relevance, and an action plan was drawn up, listing the priorities. These include taking energy efficiency and ecological aspects into account when carrying out planned projects for new construction, conversion and renovation work by using constructional thermal insulation methods (insulation, avoidance of heat loss conductors ...), the provision of technical measures such as heat recovery and reducing the running time of installations, as well as obtaining environmentally acceptable forms of energy (incl. green electricity) and energy-saving electrical appliances, avoiding idling losses when information and communication equipment is left on stand-by, and just as importantly, motivating staff to conserve energy.

Many of these measures are generally applicable and are equally relevant to the public and the private sector. It has been shown that energy consumption can be cut by up to 10 % simply by regulating and analysing the various items of equipment using electricity.

Following a temporary increase, by applying these various measures heat consumption was reduced by 10 % in 2005 compared with 1997. During this time electricity consumption had risen by 20 %. Among other things this is attributable to the clos-

Energy consumption within the sphere of responsibility of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety



Source: *Federal Environment Agency 2006 (29)* ing down and transfer of various properties, more intense utilization of properties, and the increased use of data processing technology. The increase would have been even more pronounced if these various measures had not been applied to reduce electricity consumption.

Annual heating and electrical energy statistics are balanced against the emissions of greenhouse gases and published in the form of a so-called climate barometer for the environmental department´s buildings of the BMU. Compared with 1997 there was a reduction in the emissions resulting from operation of the various properties. Since 2004 the supplies of green electricity have played an important part in this process. It was necessary to furnish proof that the generation was being provided by new plants in order to eliminate the possibility that regenerated electricity was not simply being transferred from one place to another and therefore not leading to any reduction in CO_2 emissions.

CO_2 emissions within the sphere of responsibility of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Source: *Federal Environment Agency 2006 (29)*

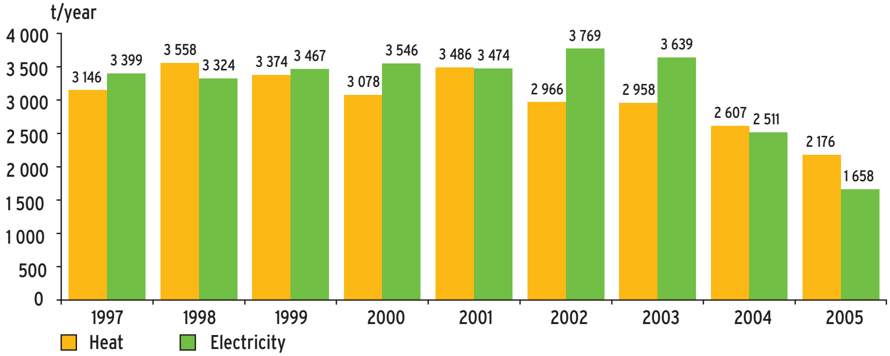
Reduction in CO_2 emissions by the Federal Environment Agency

Despite a significant rise in the number of employees in 2003 the operating emissions from properties belonging to the Federal Environment Agency only increased by 1 % compared with 1997. Since then improved heat insulation, the changeover from oil to gas and the use of green electricity have led to a reduction of around 60 % in emissions.

In addition to the introduction of environmental and energy management and the property measures referred to above, the construction of a new building in Dessau by the Federal Environment Agency, incorporating advanced energy-saving technology, has also made a valuable contribution and provides a good example for future public sector construction work.

The specific electricity and heating requirements of this ecologically designed new building are some 40 % below the levels stipulated by the Energy Saving Ordinance, placing them well below the consumption figures of conventional buildings. Impor-

CO_2 emissions by the Federal Environment Agency



Source: *Federal Environment Agency 2006 (29)*

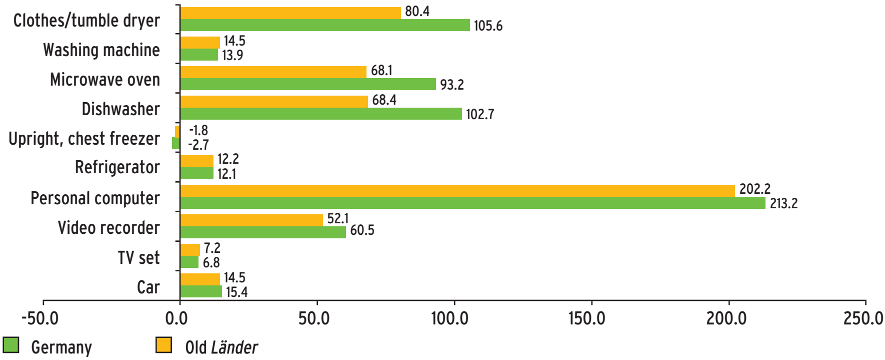
tant prerequisites in this respect are a very low ratio of surface to volume (0.33), excellent insulation of the outer structure of the building (roof, facades, floor) and highly efficiently sealing of the building.

Technical equipment in the building has been designed to make use of natural processes and to keep energy consumption to a minimum as well as making the most efficient possible use of the energy that is used. In addition to the contribution provided by the solar panels, an adsorption refrigeration unit also helps to meet the building's cooling requirements. Cooling and heating are also provided by a ground source heat pump utilizing a 5 km long horizontal geothermal collector. Electricity is also supplied by photovoltaic panels. With these various systems 15 % of the energy requirements can be produced regeneratively.

A lighting control system, dependent on daylight and human intervention, has also been installed to help reducing electricity demand.

Equipping private households with consumer durables

Extent of selected consumer durables in German private households (change 1993/2003 as %)



Source: *Federal Statistical Office 2006*

Growing prosperity and consumption in Germany over the past 30 years have also led to an unprecedented upsurge in the number of consumer durables to be found in private households. During the last 10 years the changing structure of consumption has given a further dynamic boost to the technical equipment found in private households [15].

The current levels of equipment reveal that, for the majority of German households, items such as a car, various different household appliances, consumer electronics, computers and mobile phones are taken for granted. In addition they contain numerous small technical appliances too, for example for the home and garden, hobbies, leisure and sport.

Between 1993 and 2003 the growth rates for some consumer durables have been enormous: in excess of 200 % for computers, over 100 % for dishwashers and driers, more than 60 % for video recorders [15]. Some of this growth is attributable to the "need to catch up" in the new *Länder* [16]. During the 16 years since reunification equipment levels in households in the two formerly separate states are now more or less the same [15].

In addition to the increased diffusion of technology into all parts of daily life, due to the influx of an even wider range of consumer durables, households also contain new product lines such as information and communication technology. Sooner or later this leads to an increase in the amount of information technology and the digitalization of homes, reinforced by current trends involving the "digital/multimedia networking" of the home (under the heading: smart homes), with a growing influence on our everyday lives.

Structural factors in home equipment

Selected consumer goods to be found in private households on 1.1.2005

	Households, total	Monthly net household income below/from/up to EUR				
		Under 1300	1300 – 1700	1700 – 2600	2600 – 3600	3600 – 5000
	Ownership of equipment per 100 households (% of household)					
	Vehicles and sports equipment					
Car	76.8	50.7	75.1	91.1	97.2	98.5
Bicycle	79.8	67.7	73.4	86.3	92.4	94.0
Sports equ. (home trainer)	27.3	17.2	23.8	32.3	33.8	43.4
	Equipment for receiving, recording and playing back pictures and sound					
DVD player/recorder	50.1	35.1	42.6	55.8	66.5	72.7
Video recorder	70.1	57.3	64.3	76.9	82.7	84.0
Digital camera	31.9	15.9	22.7	36.3	50.8	61.0
Analogue camera	74.9	62.6	70.7	81.4	85.8	87.2
CD player/CD recorder (incl. in PC)	69.6	58.9	67.4	73.4	79.5	84.6
	PC and communications					
Personal computer	68.6	50.9	59.1	75.0	89.4	94.3
Internet connection, access	54.6	36.6	44.1	59.5	76.8	85.5
Telephone	99.3	98.5	99.6	99.6	99.9	100.0
	Amounts of each item per 100 households (number of items of equipment)					
	Vehicles and sports equipment					
Car	101.5	53.9	83.1	116.6	152.0	170.2
Bicycle	178.1	97.4	130.8	207.1	269.1	298.3
Sports equ. (home trainer)	31.0	18.4	25.5	37.2	39.7	51.9
	Equipment for receiving, recording and playing back pictures and sound					
DVD player/recorder	63.2	39.2	48.2	70.1	91.0	106.7
Video recorder	84.7	63.1	74.1	94.7	105.4	113.9
Digital camera	36.1	16.9	24.0	40.2	58.8	73.2
Analogue camera	102.7	74.3	85.3	111.0	134.3	151.5
CD player/CD recorder (incl. in PC)	104.3	69.9	85.4	112.2	142.0	164.2
	PC and communications					
Personal computer	98.5	60.0	73.7	103.3	144.8	178.9
Internet connection, access	57.2	37.1	45.1	61.9	80.4	96.2
Telephone	241.3	169.1	206.2	261.4	316.0	368.2

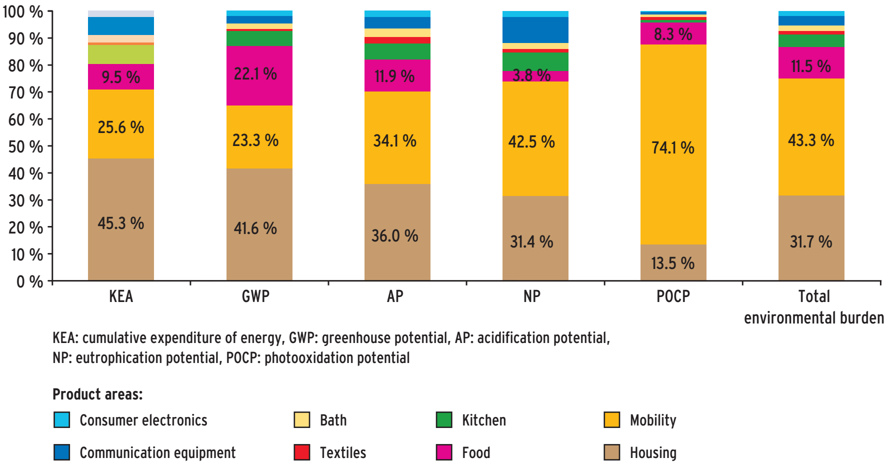
Source: *Federal Statistical Office 2006 (30)*

In addition to the degree to which households are equipped the actual stocks of equipment they contain is an increasingly important factor, providing information about the total number of consumer durables that actually exist in a household. Normally the number of items of equipment would exceed the degree equipment to which households are equipped, in the past it has been observed that they contain more than one of a particular item (e.g. the trend towards a second car).

The technical equipment found in homes may differ widely depending on the type of household, net monthly disposable income and social position of the main wage earner. A comparison of the lowest household income group shown in the table with the highest reveals that in 2005 only just over 50 % of households in the lowest income group owned a car, whereas for the highest income group the figure was 98.5 % (comparison: bicycle: 67.7 % as opposed to 94 %; personal computer: 50.9 % and 94.3 % respectively) [15]. Among the groups with a higher net household income there was a disproportionately large increase in the ownership of multiple consumer durables, especially in areas such as mobility, leisure/sport, information/communication, entertainment. This means that, because of the income situation in these households, there was a higher degree of individualization of product ownership and it was less common for these households to share products with other members of the household. In one product group, that of “telephone/mobile phone” a trend towards “total individualization” of product use (approx. 2.5 telephones/mobile phones per household) can be largely assumed [17].

The environmental relevance of the increased use of technology in private households

Contribution by product areas to individual categories of effects



Source: *Quack, D., Rüdenauer, I. 2004 (31)*

Various methodological approaches exist in environmental research (e.g. ecological balance sheets, analyses of the flows of materials, consumption indicators, general environmental account, socio-ecological research on consumption and lifestyles), which can be used to examine which areas of household consumption, on the basis of key resources and categories of effects, represent a significantly high environmental impact [18]. Despite wide differences between the methods used, the studies make comparable estimates about the environmental relevance of primary requirement areas of private sector consumption. Analyses of the flows of materials (basis: consumption and use of products by an average household) reveal that, in terms of the main factors affecting the environment, such as the cumulative expenditure of energy, greenhouse potential, acidification potential, eutrophication potential and photo-oxidation potential, and taking into account the manufacturing and use phases, the product areas of “mobility”, “housing” and “food”, have a particular high environmental relevance.

Comparable estimates are also available for all EU member states [19]. It should be pointed out that the direct and indirect environmental effects of these product categories are significantly affected by the patterns of use of private households. Estimates, for example, by the Öko-Institut, regarding selected product categories (e.g. car, heating, refrigerators), assume that approx. 2/3 of the entire environmental effects occur during the period covered by the use phase of the product [20].

Promoting sustainable products and sustainable consumption

Awareness of product labels (survey 2004)*

as %	Unknown to me	Known to me	If symbol is recognized: yes, I make note of it when shopping
Blue Angel	17	83	49
Bio-Siegel	26	74	49
TransFair logo	68	32	50
EU flower	83	17	22
FSC logo	87	13	37

* Question: Firstly I will show you five different product labels in succession. Tell me in each case, please, whether you recognize the symbol and if so, whether it influences you or not in your shopping.

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004 (32)*

Promoting sustainable products and sustainable consumption is an important task of environmental policy. According to the regular surveys by the Federal Environmental Agency to determine public environmental awareness the majority of consumers definitely support sustainable forms of consumption, e.g. by purchasing alternative, eco-friendly products. Product labels such as the national ecolabel "Blue Angel" (www.blauer-engel.de), the Biosiegel indicating that foodstuffs have been grown organically (www.bio-siegel.de) and the TransFair logo for fair trade products (www.transfair.org) can offer valuable guidance. For example, at the present time 83 % of the population in Germany is familiar with the Blue Angel and around 50 % are guided by it while shopping. It is a similar situation with the Biosiegel. In general women are more aware of environmental labels than men [21].

Attention paid to "Blue Angle" by shoppers

Proportion by % of those questioned who look out for the "Blue Angel"	Total	1993	1994	1996	1998	2000	2002	2004
Those questioned	Total	53	52	47	44	40	39	49

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004 (33)*

Despite a considerable willingness to pay more for eco-friendly and Fair Trade products, they still only have a very small share of the market. Nevertheless, in 2005 the sales of Fair Trade food products rose by 22 % to just under 121 mi. euros, and products carrying the Biosiegel achieved estimated sales of 3.9 bi. EUR and double-digit growth rates. This represents a market share of just under 5 % of all the food products sold in Germany [22].

New forms of consumer information about the possibilities for sustainable consumption have been introduced in order to increase demand for sustainable products. For example the German Council for Sustainable Development has developed a "Sustainable Shopping Basket – A Guide to Future-Orientated Consumption" to offer guidance on sustainable products and services in such consumption areas as food/nutrition, textiles/clothing, housing/supplies, mobility/transport, tourism/travel and financial services.

Another example, which has been developed by the Öko-Institut, is the "EcoTopTen" concept which focuses on high innovative standards for specific products and applies criteria such as environmental properties, better than average quality features, ratio of price to performance, life cycle costs or subsequent costs, which are incorporated in the assessment during the utilization phase. In accordance with this assessment the EcoTopTen products are regularly chosen from ten product categories which are particularly relevant to sustainable consumption in terms of their environmental qualities and their cost, and these are then published in the form of "Product Rankings".

Quality labels and labelling for sustainable consumption – examples

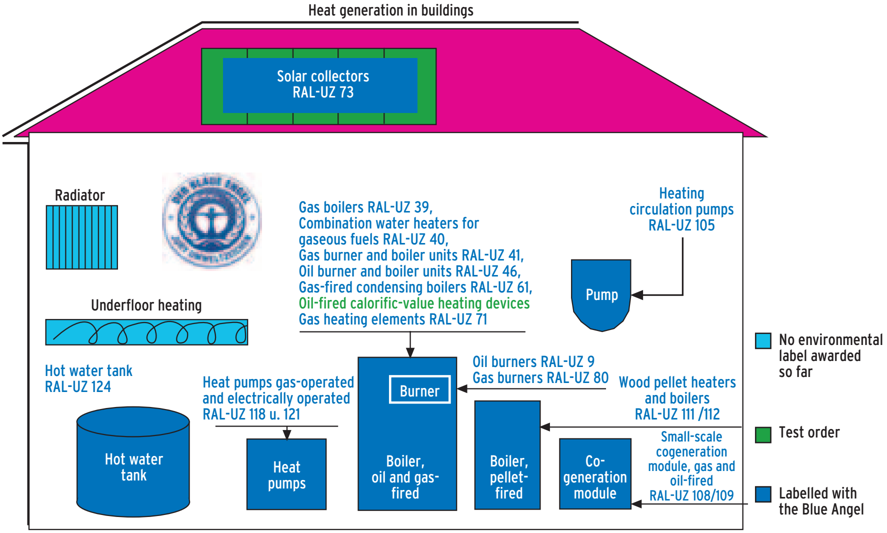
Quality label/ecolabel		Homes	Food	Textiles	Mobility	Tourism/ Travel	Finance
Blue Angel Environmentally friendly products		x			x		
European Ecolabel (EU flower) Environmentally friendly products and services*		x		x		x	
European Energy Label Efficient energy consumption by electrical appliances	Various Labels	x					
Forest Stewardship Council (FSC) Certified wood products from environmentally appropriate, socially beneficial, and economically viable (sustainable) forest management		x					
Grüner Strom Label e.V. Electricity from renewable energy sources		x					
Öko-Test Comparative product testing		x	x	x	x		x
Stiftung Warentest Comparative product testing		x	x	x	x	x	x
Rugmark Adherence to minimum social standards in the production of carpets and rugs				x			
Bio-Siegel Products and foodstuffs produced and controlled according to the provisions of the EU Regulation on Organic Farming			x				
Marine Stewardship Council Fish from sustainable fisheries			x				
TransFair Using fair trade to assist producers in developing countries			x				
Viabono Umbrella label for environmentally responsible tourism						x	
VCD Auto-Umweltliste Environmental compatibility of 300 cars examined, and of the environmental commitment of manufacturers					x		

* Ref. source: http://ec.europa.eu/environment/ecolabel/index_en.htm

Source: *German Council for Sustainable Development 2006 (34)*

Environmentally friendly heating systems bearing the Blue Angel label

Application of the Blue Angel to heat generation



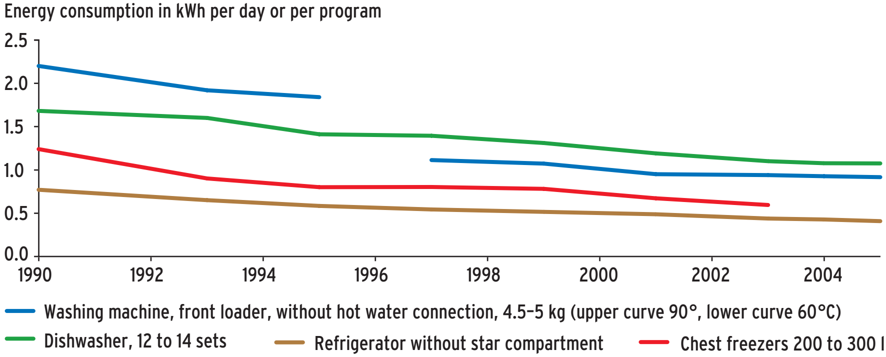
Source: *Federal Environment Agency 2006 (29)*

The Blue Angel label can be displayed by particularly efficient, low emission heating systems burning gas, oil or wood pellets, by small unit-type heating plants small-scale congeneration modules heat pumps and, most recently, by energy-saving hot water tanks. What they all have in common is that they are based on technical standards which are stricter than those required by law, and that the Blue Angel criteria are regularly tightened to reflect changes in the market. In this way the Blue Angel has made a significant contribution to the commercial introduction of newer, highly efficient heating systems which help to protect the environment. In September 2006 the Blue Angel was awarded to 100 heating installation products. This symbol indicates to the purchaser of a heating system that items bearing the Blue Angel have a particularly low level of emissions and are energy-saving.

The Blue Angel can be awarded to oil and gas-fired heating systems that satisfy the criteria for efficient energy use (e.g. in terms of the degree of utilization, emission limits, heat loss rate, electricity consumption and other requirements) as listed under www.blauer-engel.de.

Development of electricity consumption by large domestic appliances

Development of electricity consumption by large domestic appliances in Germany



Source: *Federal Environment Agency 2006 (35)*

Improving the energy efficiency of private households is also of major importance. Between 1990 and 2005 there was a decline in the energy consumed by large domestic appliances, which includes units for heating water (washing machines and dishwashers) as well as mechanical energy, and this applied to all groups of appliances.

The introduction of the EU energy label, which advises potential purchasers about the energy efficiency of electrical domestic appliances, has contributed to this improvement. These labels have been available since 1.1.1998 for refrigerators, freezers and washing machines, driers and combined units (i.e. washer/driers), since 1.3.1999 for dishwashers, since 1.7.1999 for domestic lamps and since 1.1.2003 for air conditioning units.

Assistance for anyone considering the purchase of electrical and electronic equipment is also provided by the Blue Angel and, in Germany, by the GEEA (Group for Energy Efficient Appliances) label awarded by Gemeinschaft Energielabel Deutschland.

Although considerable savings can be achieved these are cancelled out by an increase in consumption. It is particularly wasteful to allow appliances to consume energy without actually fulfilling their intended function, i.e. by allowing them to idle or remain on stand-by. The Federal Environment Agency has calculated that at least 11 % of the electricity consumption by private households is attributable to equipment being left idling or on stand-by. Stand-by is the most well known form but is by no means the only cause of such wastage. For example equipment such as audio and hi-fi systems frequently consume electricity when the switch is in the “off” position, because they have not really been turned off at all. In many cases stand-by or idling losses can only be avoided by isolating the equipment completely from the mains supply. According to projected figures for the whole year, the cost of leaving equipment idling or on stand-by in private households and offices in Germany is 3.5 bi. euros (at 18 ct/kWh for private households, details correct as per January 2004).

Water consumption by private households

Absolute consumption of drinking water in households and small businesses[1)]

	1991	1995	1998	2001	2004
Water supplied to households and small businesses (mi. m^3)	4127.8	3872.0	3814.0	3779.1	3752.3
Water supplied to households and small businesses (l/(pc*d))[2)]	144	132	129	127	126

1) From public water supply

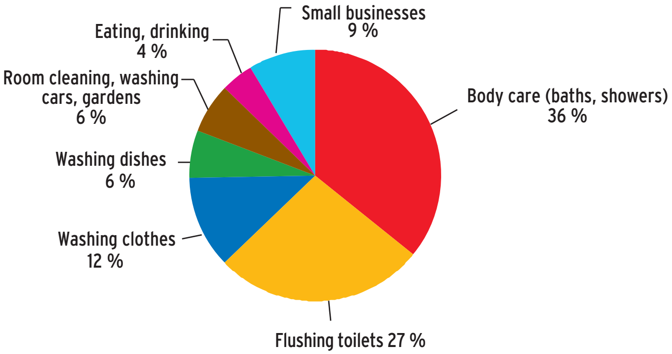
2) Pertaining to connected residents

Source: *Federal Statistical Office 2006 (36)*

There has been a 9.1 % decline in absolute terms in the amount of drinking water consumed by private households and small businesses during the period under review and in 2004 it totalled 3 752,3 mi. m^3.

In Germany 99 % of the population is connected to the public water supply, a figure that enables the per capita consumption of drinking water to be accurately determined. Over the same period per capita consumption of drinking water in Germany declined by 12.5 % and now stands at 126 l per head of population per day. However, it should be borne in mind that these figures also include the water consumed by small businesses. According to the estimates of the Federal Association of the German Gas and Water Management small businesses account for an average of 9 % of the total quantity supplied. This corresponds to 11 l/(p.c.*d). Accordingly the average consumption by German households is approx. 115 l/(p.c.*d), of which only about 4 % is used in homes as drinking water, while 63 % of the drinking water used is accounted for by body care (baths, showers) and flushing toilets.

Water use in home 2004 (average values, with reference to water dispensed to households and small businesses)



Source: *Federal Association of the German Gas and Water Management 2006 (37)*

Land area used by private households

Settlement area, building and adjacent open area, actual living area in private households, members of household, households (1995 and 2004)

	Unit of measurement	1995	2004 Absolute	2004 1995 = 100
Settlement area	km^2	12 659 1)	14 678	115.9
Building and open area				
Used for housing	km^2	8 748 1)	10 004	114.4
Actual living area	mi. m^2	2 841	3 213	113.1
Members of household	1 000	80 845	81 906 2)	101.3
Households	1 000	36 532	38 607 2)	105.7
Actual living area used by each member of household	m^2	35	39	111.6
Actual living area used per household	m^2	78	83	107.0

1) Reference year 1996

2) Estimates (annual average)

Source: *Federal Statistical Office 2006 (6)*

Private households occupy 52 % of the total settlement area, primarily for housing purposes. That part of the area occupied by settlements which is not used for housing includes recreational areas, cultivated gardens and cemeteries.

Between 1996 and 2004 the proportion of settlement areas occupied by households increased by 15.9%. The amount of building and adjacent open area mentioned above increased at a slightly lower rate, by 14.4 %.

In comparison, the actual living area rose by 13.1 % between 1995 and 2004 (and by 11.5 % between 1996 and 2004). A number of factors are responsible for the different rates of development of the actual living area and the amount of building and adjacent open area. These include a higher proportion of unused living areas (empty housing), the fact that new construction includes a substantially increased proportion of single family homes, which require more land, and a greater building density, especially in the inner cities.

Over the last decade the number of single and two-person households has risen by some 12 %, contrasting with a 7 % decline in households containing with two or more persons. The trend towards smaller households imposes additional pressures on the use of living areas. At 62.5 m^2 the amount of living space per person in single person households is significantly higher than in two person households (43.4 m^2). Members of households containing three of more persons only occupy an average area of 28.5 m^2, which is less than half that of single person households.

Total amount of waste produced

Waste production in thou. t

	2002	2003	2004*
Waste from settlements	52 772	49 622	48 433
Mining waste	45 461	46 689	50 452
Waste from manufacturing sector	42 218	46 712	53 010
Building and demolition waste (incl. road construction waste[1)])	240 812	223 389	188 607
Total	**381 262**	**366 412**	**340 501**

* Provisional figures

1) From 2004 excludes excavated soil, building rubble and road construction waste from public sector works

Source: *Federal Statistical Office 2006 (38)*

In Germany in 2004 waste production totalled 340.5 mi. t. Of this almost two thirds (55 %) consisted of building and demolition waste, followed by waste from manufacturing and industry, with 16 %, mining tailings with 15 % and waste from settlements, amounting to 14 %. There has been a continuous decline in the amount of waste produced since 2002, which has decreased by 11 %. In 2004 25.9 mi. t less waste was taken to disposal sites than in the previous year. This decline is mainly due to the decrease in the amount of construction and demolition waste (– 16 %). In 2004 the majority of the waste from settlements consisted of non-hazardous household waste, amounting to 42.9 mi. t or 89 %. Household waste includes the 16.9 mi. t (39 %) of separately collected categories such as glass, paper, light packaging etc., followed by household refuse with 15.6 mi. t (36 %), that are removed by the public refuse collection service. The proportion of biodegradable garden and park waste amounted to 10 % (4.2 mi. t). A further 9 % (3.7 mi. t) is made up of compostable waste (organic waste bin) and 6 % of bulky refuse, with 2.6 mi. t.

Production of waste from settlements in thou. t

	2002	2003	2004*
Total household waste	**46 660**	**43 931**	**43 149**
of which, no special monitoring required	46 420	43 668	42 878
Domestic refuse, commercial waste similar to domestic refuse, collected by public refuse collection service	17 090	15 824	15 558
Bulky waste	2 933	2 608	2 589
Compostable waste from organic bins	3 465	3 447	3 661
Biodegradable garden and park waste	4 163	3 845	4 172
Other items collected separately (glass, paper, plastics, electronic components)	18 769	17 944	16 899
Total of other waste from settlements	**6 112**	**5 691**	**5 284**
of which, no special monitoring required	6 112	5 679	5 265
Commercial waste similar to household refuse, not collected by public refuse collection service (excl. household refuse and bulky waste)	5 092	4 718	4 143
Garden and park waste (including waste from cemeteries)	216	210	316
Street cleaning, market waste	803	752	806
Total	**52 772**	**49 622**	**48 433**

* Provisional figures

Source: *Federal Statistical Office 2006 (38)*

Recovery rates for main waste streams

Utilization of waste

		2002	2003	2004*
Total waste production	**Thou. t**	**381 262**	**366 412**	**340 501**
Of which: utilized	**Thou. t**	**252 075**	**241 272**	**220 763**
Utilization ratio	**%**	**66**	**66**	**65**
Of which:[1]				
Waste from settlements	thou. t	52 772	49 622	48 433
Of which: utilized	thou. t	29 743	28 854	27 810
Utilization ratio	%	56	58	57
Waste from manufacturing industries	thou. t	42 218	46 712	53 010
Of which: utilized	thou. t	16 260	19 793	30 060
Utilization ratio	%	39	42	57
Building and demolition waste (incl. road construction waste)[2]	thou. t	240 812	223 389	188 607
Of which: utilized	thou. t	206 076	192 626	162 893
Utilization ratio	%	86	86	86
For information only:				
Waste requiring special monitoring (hazardous waste)[3]	thou. t	19 636	19 515	18 452
Of which: utilized	thou. t	5 056	5 374	12 632
Utilization ratio	%	26	28	68

* Provisional figures

1) Mining waste is deposited solely above ground on tips or heaps

2) From 2004 excludes excavated soil, building rubble and road construction waste from public sector works

3) Waste requiring special monitoring is only included for Information purposes because it is already included under other headings

Source: *Federal Statistical Office 2006 (38)*

In principle the Recycling Law is intended firstly to avoid the production of waste material, and secondly to exploit any waste materials or use them to produce energy. A very high proportion of building and demolition waste was utilized, in excess of 85 %, during the period under consideration, 2002 to 2004. Substantially increased utilization was achieved of the waste from manufacturing industries and of the refuse requiring special monitoring, whereas the proportion of utilized refuse from settlements remained roughly unchanged between 2002 and 2004 at an average figure of 57 %.

Disposal rates for main waste streams

Waste deposition

		2002	2003	2004*
Overall waste production	**Thou. t**	**381 262**	**366 412**	**340 501**
Of which: deposited	**Thou. t**	**108 325**	**103 855**	**103 237**
Deposition ratio	**%**	**28**	**28**	**30**
Waste from settelements	thou. t	52 772	49 622	48 433
Of which: deposited	thou. t	11 266	9 530	8 578
Deposition ratio	%	21	19	18
Mining waste	thou. t	45 461	46 689	50 452
Of which: deposited	thou. t	45 461	46 689	50 452
Deposition ratio	%	100	100	100
Waste from manufacturing industry	thou. t	42 218	46 712	53 010
Of which: deposited	thou. t	20 857	20 757	18 792
Deposition ratio	%	49	44	35
Building and demolition waste (incl. road construction waste)[1)]	thou. t	240 812	223 389	188 607
Of which: deposited	thou. t	30 741	26 878	25 415
Deposition ratio	%	13	12	13
For Information only:				
Waste requiring special monitoring (hazardous waste)[2)]	thou. t	19 636	19 515	18 452
Of which: deposited	thou. t	5 545	5 035	3 568
Deposition ratio	%	28	26	19

* Provisional figures

1) From 2004 excluding excavated soil, building rubble and road construction waste from public sector construction and recultivation works

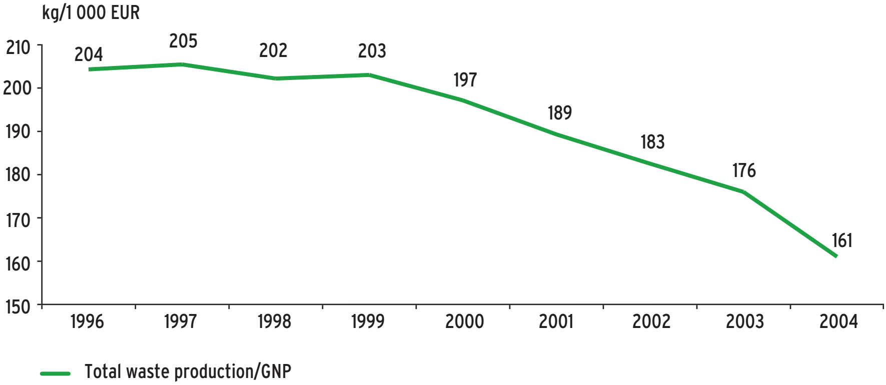
2) Waste requiring special monitoring is only shown for information purposes because it is already included under other headings

Source: *Federal Statistical Office 2006 (38)*

There has been a decline in the proportion of waste from the manufacturing industries that has been deposited. Whereas in 2002 out of a total of 42.2 mi. t 49 % was deposited, by 2004 the rate had fallen to 35 %. This represents a 29 % decline in the proportion deposited. Even though, during the period under consideration, from 2002 to 2004, the proportion of settlement waste that was deposited was not as significant as that from manufacturing industry, nevertheless, proportionately, the difference in the amounts deposited, from 11.3 mi. t (21 %) to 8.6 mi. t (18 %), does represent a 14 % reduction. During the period under consideration the overall proportion deposited remained relatively constant at 30 %.

Waste intensity

Waste intensity (waste production with reference to gross national product, price-adjusted)



Source: *Federal Statistical Office 2006 (38)*

The creation of closed cycles of materials assumes major importance as part of a sustainable policy aimed at protecting natural resources. The basic principles of this recycling system are laid down in the Recycling and Refuse Law, with priority being given to making as much use as possible of materials obtained from the natural world in order to avoid the production of waste. The intention is to decouple the creation of waste from economic expansion. Unavoidable waste should be correctly and harmlessly utilized or disposed of in an environmentally acceptable way.

Although economic output rose slightly between 1996 and 2004, the volume of waste during the same period fell continuously. Much of the reason for this reduction in the amount of waste being produced over recent years has been the decline in building and demolition waste as a consequence of the economic situation. Waste intensity, i.e. the total amount of waste produced measured against the development of the gross national product (adjusted to take price changes into account), fell during the period under consideration by 21 percentage points from 204 kg/thou. euros to 161 kg/thou. EUR.

RESOURCE USE AND OVERALL ECONOMIC OUTPUT

Intensity of the use of resources

Resource intensity, the proportion of a utilized environmental resource (in non-monetary units) to the price-adjusted gross domestic product, is a way of measuring the efficiency with which an economy makes use of natural resources. The more intensively a natural resource is used in relation to the economic added value, the more harmful the pressures on the environment and so far apart from sustainable development the activity is. In German sustainability strategy the reciprocal value of the intensity, the so-called productivity, is used as an indicator for the use of the input factors of raw materials and primary energy.

The intensity of the environmental factors of raw materials, energy, land area, water, atmospheric emissions and, as an indirect measure, transport services, *applied* in Germany is presented below. The resource intensity trend is considered in terms of the economy as a whole and according to production sectors, in order to be able to determine the extent to which individual sectors contribute to pressures on the environment. Considering the environmental pressures in connection with the driving forces in production and consumption is an essential basis for environmental policy measures.

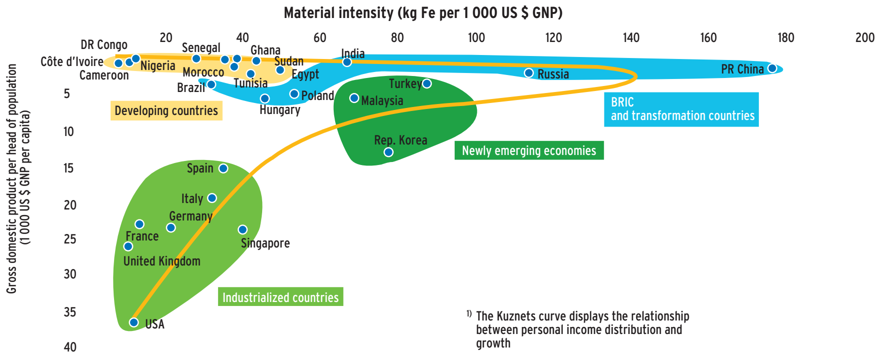
The consumption of natural resources is determined by various factors such as economic growth, changes in the economic structure and the intensity with which resources are used in individual sectors. Decomposition analyses is used to provide a clearer picture of these interacting effects. A decomposition analysis enables the influence of the factors referred to previously to be investigated in greater detail. Each individual effect describes how the consumption of the resource would have developed given an exclusive change to the observed influencing factor.

The overall economic consideration focuses on the base years of the national sustainability strategy (as a rule 1990). However, the industry-related views of the development in the intensity and an analysis of this development generally refer to the base year 1995, so that any examination of the past or preview of the future is not affected by the particular developments that took place in the early 1990s as a result of German reunification.

The natural resources used domestically are taken into consideration when calculating the respective indicator of intensity, i.e. the subject under review is the domestic environment. One consequence of the globalization trend of recent years, which is evident, for example, in an intensified network of foreign trade, has frequently been the relocation of environmentally intensive production to other countries. The ensuing pressures on the environment, such as the consumption of energy and raw materials (utilized and non-utilized extraction), and water, the use of land areas and the emissions of residual materials and pollutants, are therefore assigned to the particular country where they take place and not to the users of the products.

Using an input-output analysis the data in the Environmental Economic Accounting enables an estimate to be made of the indirect pressures associated with the manufacture of imported and exported goods. Such findings are constantly being obtained and published as part of the Environmental Economic Accounting.

Intensity of use of raw steel in countries at different stages of development (Kuznets curve)[1)]



Source: *Federal Institute for Geosciences and Natural Resources 2006*

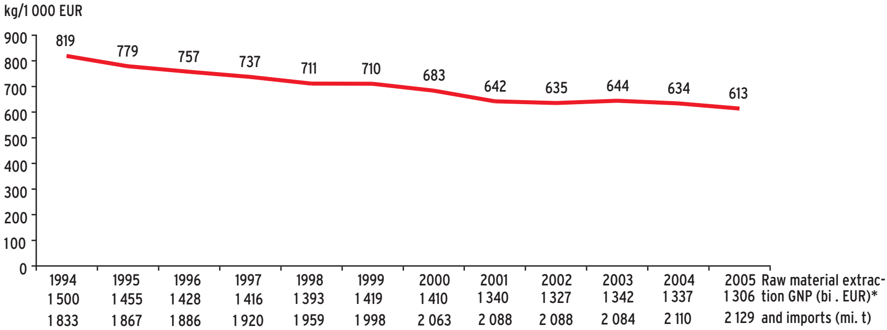
One way of assessing the efficiency with which resources are used is provided by the indicator of raw material intensity or the intensity with which materials are consumed (raw material consumption per unit of GNP in terms of per capita GNP). This indicator presents the development of the GNP as a typical bell-shaped curve, known as a Kuznets curve, as shown in the diagram, using steel as an example.

A comparison of several countries reveals the typical sequence of low material consumption with a relatively low GNP, which is typical of developing countries, through the high consumption with increased GNP characteristic of emerging countries, to the low consumption levels in countries with the highest per capita incomes in the world. The historical development of the intensity of consumption in Germany can be graphically displayed using a Kuznets curve. The development leading to the lowest intensity of consumption reflects not only the growing importance of the tertiary service sector in the Germany economy but also the learning curve associated with the more efficient use of the particular raw material.

Germany's current position in the Kuznets diagram indicates that around 20 kg of steel is required to generate 1 000 US$ of GNP, an amount similar to the situation in Peru. However, per head of population in Germany, with an input of 20 kg of steel approximately 24 000 US$/per capita (real GNP, base year 2000) is generated, which is around ten times the per capita GNP of Peru. The input of resources depends to a large extent on the stage of development attained by the infrastructure. Infrastructural development in Peru is still at a very low level, whereas in Germany it has been largely completed. China is currently in the middle of its infrastructural expansion phase and consequently its demand for steel is very high. This development tends to apply not only to steel but also to other mineral and energy-providing raw materials.

Raw material intensity

Development of raw material intensity in Germany



* Price adjusted, interlinked volume

Source: *Federal Statistical Office (6)*

Raw material intensity is an indicator of the mass of the abiotic raw materials and goods used by the economy in relation to the gross national product, with the tonnages of the various raw materials and of imported semi-finished and manufactured goods being included equally in the calculations.

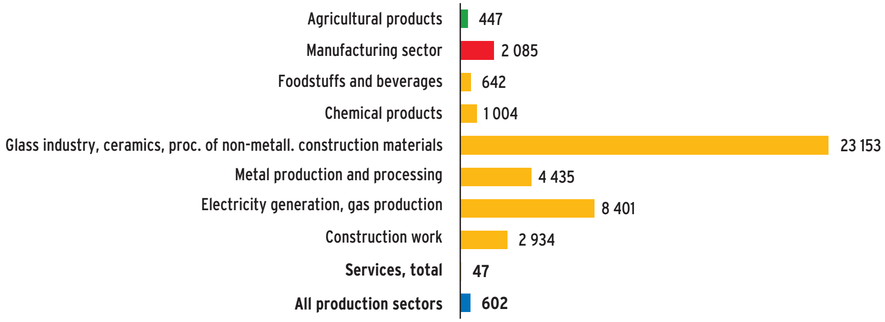
Individual ecological weighting does not currently take place, with the result that the material components of the indicator are determined by quantitatively dominant, domestically extracted mineral raw materials (sand, gravel), while the raw materials which are unimportant in terms of their weight but are certainly relevant in an environmental and health context, play hardly any part in this process. Thus, in the case of copper, for example, neither the substantial quantities of strip waste and refuse produced abroad ("ecological backpacks") nor the contamination produced by their pollutants are taken into consideration.

Therefore raw material intensity can only be used as an approximate indicator for the environmental burden. The extraction and use of a raw material are always accompanied by demands on land area, materials and energy, the storage of materials and the emission of pollutants. Therefore raw materials must be used sparingly and efficiently. Greater in-depth analysis is needed in order to be able to make more precise statements about the environmental burden.

It is the German government's aim to double raw material productivity by 2020 compared with 1994, which corresponds to a reduction by half in the raw material intensity. Between 1994 and 2005 raw material intensity fell from 819 kg/thou. EUR to 613 kg/thou. EUR, i.e. by an average of approx. 18.7 kg/thou. EUR annually. However, this development has definitely eased off in recent years, and the past three years have seen an average annual reduction of only 7.3 kg/thou. EUR. Raw material intensity will have to fall to 410 kg/thou. EUR by 2020, an annual average of 13.5 kg/thou. EUR, if the government's target is to be met. This means that, in comparison with the past few years, increased efforts will be needed.

Raw material intensity according to production sectors

Material intensity*) according to production sectors 2004



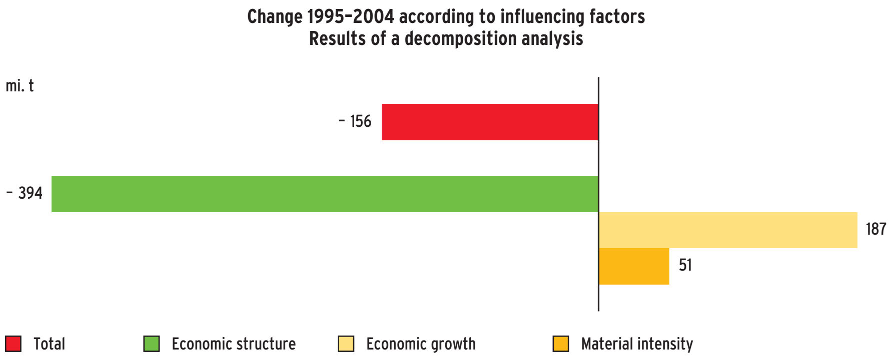
*) kg material input per 1 000 EUR gross added value (at respective prices)

Source: *Federal Statistical Office 2006 (6)*

The level of material intensity for individual production processes differs widely, depending on the particular technical conditions. For example the average material intensity in the manufacturing sectors in 2004 was 2 085 kg/thou. EUR, whereas for services the average was only 47 kg/thou. EUR. A number of sectors within the manufacturing sector were extremely material-intensive, and these included “glass, ceramics, non-metallic building materials” (23 153 kg/ thou. EUR), “metal production” (4 435 kg/thou. EUR), “electricity and gas” (8 401 kg/thou. EUR) and “construction work” (2 934 kg/thou. EUR). Changes to the input of materials in these material-intensive production areas have a significant impact on the raw material indicator for the economy as a whole.

Effects on the use of materials due to structural factors, intensity and growth (decomposition)

Material consumption by the production sectors



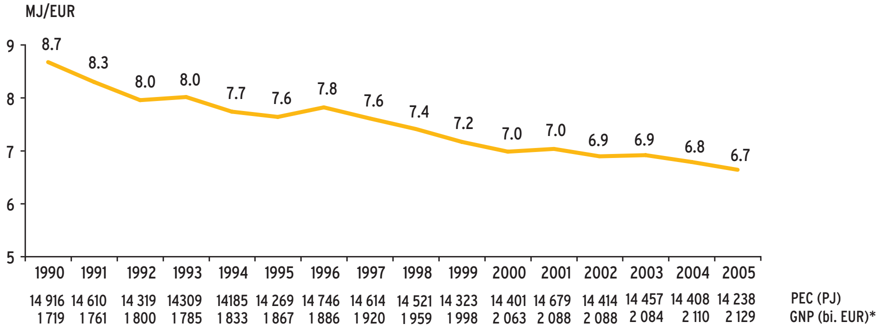
Source: *Federal Statistical Office 2006 (6)*

In total, during the period 1995 to 2004, the input of materials in the production sectors fell by around 156 mi. t as the result of some widely differing effects.

Between 1995 and 2004 the change in the economic structure, i.e. the different rates of growth of the production sectors, led to a sharp reduction in consumption, by −394 mi. t. This can be attributed above all to the decline in economic output by those production sectors which have a relatively high input of materials. This applies in particular to construction. In contrast economic growth of + 15.7 % (price-adjusted gross added value of the production areas), with no changes taking place in other conditions, would have led to increased consumption of approx. 187 mi. t. The intensity effect pertaining to individual sector also led to increased consumption (+ 51 mi. t). Thus the overall economic intensity of the primary materials deployed is attributable solely to a structural change leading to less material-intensive sectors.

Energy intensity

Development of energy intensity in Germany



* Price adjusted, interlinked volumes

Source: *Federal Statistical Office 2006 (39)*

Energy intensity is an indicator that describes the efficient use of energy. It shows how many units of primary energy are needed in order to produce one monetary unit of gross national product (GNP). The diagram shows that there has been a significant decline in energy intensity in Germany. Whereas in 1990 the creation of one EUR worth of GNP still required 8.7 MJ, by 2005 this had fallen to only 6.6 MJ. For many years now the consumption of primary energy has fallen very little. It is currently 4.5 % below the 1990 value, whereas the GNP has risen by some 24 % over the same period. Thus energy consumption has to a certain extent been decoupled from economic growth.

In particular improvements to power stations (new and converted plants, increased efficiency) and the exploitation of energy saving potentials in all areas of the economy and in private households have helped to reduce the energy intensity.

The aim of the National Sustainability Strategy is to double energy productivity by 2020, with a corresponding halving of the energy intensity. Germany can only attain this objective if a range of other measures are also undertaken. For example, the efficiency of coal- and gas-fired power stations could be improved by around 50 %. Power stations using combined heat and power technology reduce the energy losses of the primary energy used by between 10 and 20 %, which is a compelling reason for continued development of the Combined Heat and Power Act. Building renovation to improve efficiency, supported by such instruments as the energy pass and the collected heating data, known as the “Heizspiegel”, offer additional possibilities for achieving savings. The high and continuing upward trend in the amount of electricity used by private households could be reduced by at least 11 % if electrical appliances were not left on stand-by or idling.

Energy intensity according to production sectors

Primary energy intensity*) according to production sectors 2004

*) Energy consumption in MJ per 1 000 EUR gross added value (price adjusted)

Source: *Federal Statistical Office 2006 (6)*

The energy intensity of production sectors can be found by using the ratio of the energy input (energy content in joules) to the gross value added achieved (in EUR). The analysis of the development over time of the energy intensity takes as its basis the price-adjusted gross value added of the production sectors.

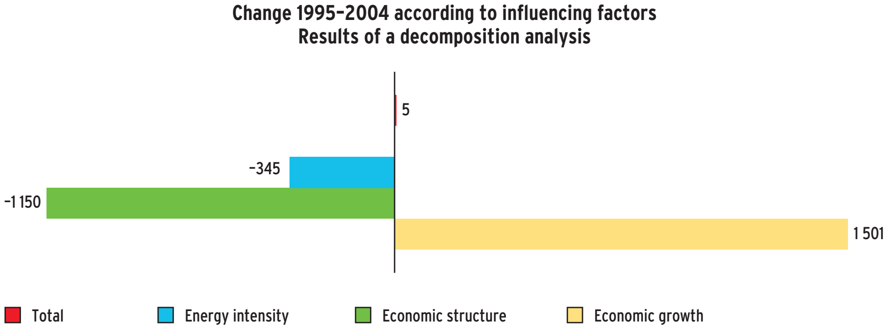
The level of material intensity for individual production processes differs widely, depending on the particular technical conditions. Thus, in 2004 the energy intensity for the manufacturing sectors averaged 11.0 MJ/EUR. The use of energy was particularly intensive in the sector of “chemical products” (47.1 MJ/EUR) and “metal production and processing” (55.2 MJ/EUR).

Between 1995 and 2004 the energy intensity of the production sectors declined overall by 13.9 %, giving an annual average decline of 1.9 %. This decline is attributable above all to the increase in gross value added of just under 16 % during this period, whereas primary energy consumption in the production sectors remained largely unchanged.

Energy intensity fell in almost all sectors, for example by an average of 5.9 % in manufacturing . Within the manufacturing sector the decline was particularly pronounced in the sectors of “food and beverages” and the “chemical industry”, by 10.8 and 6.6 % respectively. Within the service sector the intensity fell by 13.1 %. Due to the growing contribution made by the service sector to overall economic output, the high increase in efficiency in this sector is a significant factor in the increased energy productivity in the economy as a whole.

Influences on energy consumption due to structural factors, intensity and growth (decomposition)

Energy consumption by production sectors



Source: *Federal Statistical Office 2006 (6)*

Using decomposition analysis the change in energy consumption by production areas can be traced back to the following three factors:

- **Economic growth** – measured by the sum total of the price-adjusted gross value added of the production sectors,
- **Economic structure** – the share of the production sectors in the total gross a value added,
- **Energy intensity** – ratio of primary energy consumption (in joules) to the price-adjusted gross value added (in EUR) for each production sector.

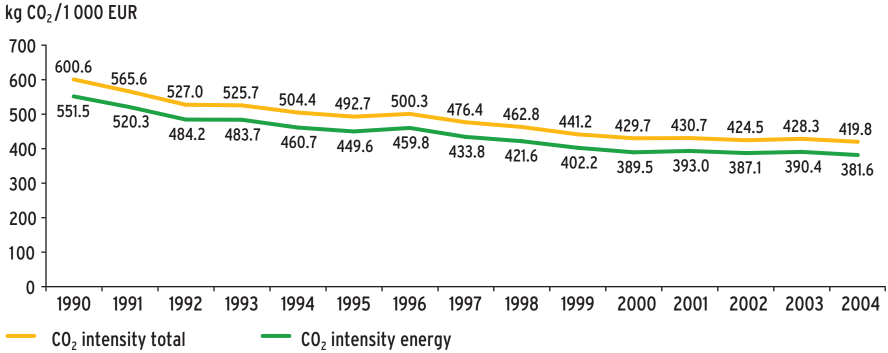
The energy consumption by the production sector changed only very slightly over the period from 1995 to 2004. In 2004 consumption was 10 250 PJ, which is only slightly above the 1995 level (10 245 PJ). However, the influencing factors affect consumption in widely differing ways.

If conditions had remained unchanged, economic growth of + 15.7 % during this period would have led to an increase in consumption of approx. 1 501 PJ. In contrast the change in the economic structure, i.e. the varying rates of growth in the production sectors, with an effect of 1 150 PJ or – 11 %, sharply reduced consumption. This is attributable to the above-average growth of the production sectors, especially the service sectors, together with a below-average energy input.

The decrease in energy intensity in individual production sectors also tended to inhibit consumption by around – 345 PJ or – 3 %. In almost all production sectors the energy input in relation to the economic output achieved was substantially reduced. For example the energy input in the manufacturing sector fell between 1995 and 2004 by over 5 % while economic output rose over the same period by 15 %. Energy savings due to technological improvements, combined with the transfer of energy-intensive processes to other countries, were the factors contributing to this improved efficiency.

Emission intensity

CO_2 intensity of German industry



Source: *Federal Environment Agency 2006 (40)*

In Germany carbon dioxide accounts for 97 % of the energy-induced emissions of greenhouse gases (UBA, as per October 2006), while the intensity of CO_2 emissions as a whole and of energy-induced emissions has fallen by some 30 % over the past 15 years.

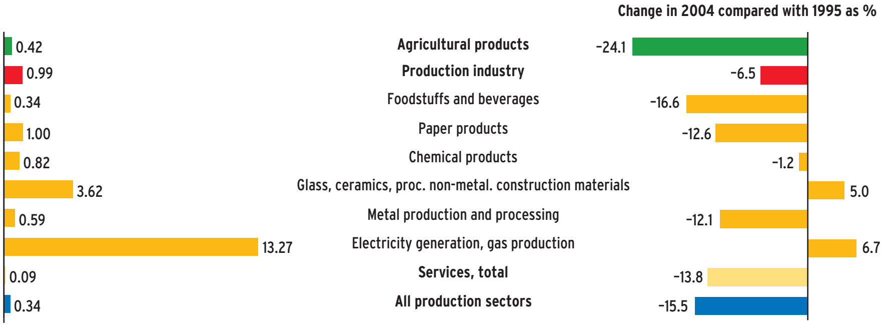
This trend for more CO_2 to be released counteracts that of the gross national product, which is an indication of a separation in absolute terms of economic development from the stresses imposed on the environment within Germany. However, the relative change in emissions is below the rate of the change in economic added value. The reduced CO_2 emissions can be explained by the changeover from solid to liquid and gaseous low carbon fuels and the growing share accounted for by renewable energy sources, declining conversion losses, the improved efficiency of new installations, and various energy conservation measures.

It should, however, be borne in mind that emissions accounted for by imports, which are associated with the extraction of raw materials and the production of semi-finished and manufactured goods abroad for the domestic German economy (ecological back-packs), have not been considered here because precise figures are not yet available.

During the period under consideration, from 1990 to 2004, the reduction in the intensity of CO_2 emissions has been more pronounced than the decline in energy intensity. This is attributable to the special effect produced by changes in the composition of the primary energy sources in favour of low-carbon energy forms and renewable energy.

Emission intensity according to production sectors

CO_2 intensity*) according to production sectors



*) kg CO_2 emissions per EUR gross added value (price adjusted)

Source: *Federal Statistical Office 2006 (6)*

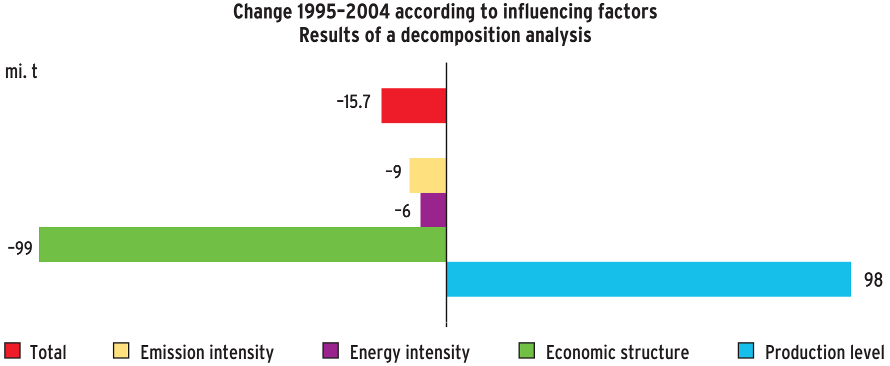
The level of CO_2 intensity in kg CO_2 emissions per EUR of gross added value differs widely, depending on the varied technical production conditions in different areas of the economy and of manufacturing.

On average the manufacturing sector almost exactly achieves **1 kg CO_2 emissions per EUR of added value**. Due to the processes involved, the “electricity generation and gas production” and the “manufacture of glass, ceramics, processing of non-metallic construction materials” is well above the average. Other areas of the manufacturing industries are well below the average. Agriculture too (0.42) and the service sector in particular (0,09) are significantly below the average for the manufacturing industries. The average figure for all production sectors is 0.34 kg CO_2/EUR gross added value.

The diagram shows the change over time in the CO_2 intensity in 2004 compared with 1995. In the production sectors of “glass, ceramics, processing of non-metallic construction materials” and “electricity generation and gas production” alone the CO_2 intensity increased (5 to 6.7 %), whereas it fell, sharply in some cases, in the other areas (e.g. agriculture – 24.1 % and all services – 13.8 %).

Influences on CO_2 emissions due to structural factors, intensity and growth (decomposition)

CO_2 emissions by production sectors



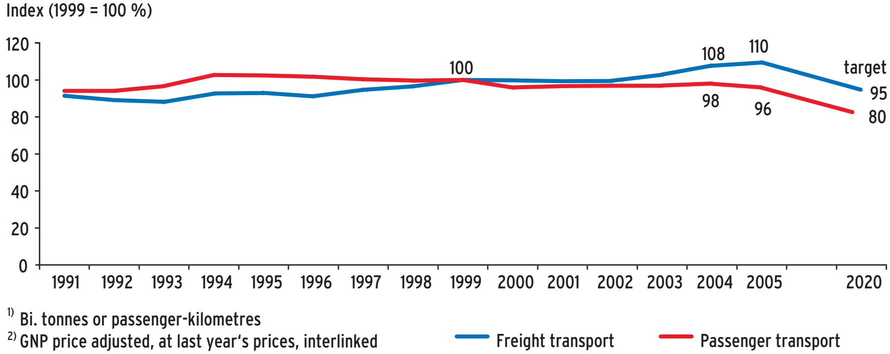
Source: *Federal Statistical Office 2006 (6)*

The influences referred to in the heading are exemplified in the above diagram by the following factors: The "production level" represents the "shift in demand", the factor "economic structure" refers to the "structural change" and the factors "emission intensity" and "energy intensity" reflect increased efficiency.

The decomposition analysis reveals that, of the four factors considered, only one acts in the direction of an "increase in CO_2 emissions" - that of the production level. If all other influencing factors had remained constant throughout the period under observation, from 1995 to 2004, this factor would have produced an increase of 98 mi. t. However, the influence of the production level is balanced by the influence of a change in the economic structure, leading to a reduction in emissions (intensifying the activity of less polluting production sectors with a simultaneous reduction in those sectors exposed to pollution). The increase in efficiency, expressed by a change in the intensity of emissions and energy, is, however, only slight, thus contributing to a slight reduction in emissions.

Intensity of passenger and freight transport

Transport intensity (transport volume[1] per 1 000 EUR GNP[2])



[1] Bi. tonnes or passenger-kilometres
[2] GNP price adjusted, at last year's prices, interlinked

Source: *Federal Ministry of Transport, Building and Urban Affairs 2006 (41)*

As part of a process of sustainable development it is desirable to improve transport efficiency while retaining a high level of mobility, as a way of cutting down the burdens that transport imposes on mankind and the environment. Transport intensity as a ratio of transport volume to the gross national product is a way of measuring transport efficiency. The figures show the amount of transport volume "required" in freight and passenger transport per unit of gross national product (GNP).

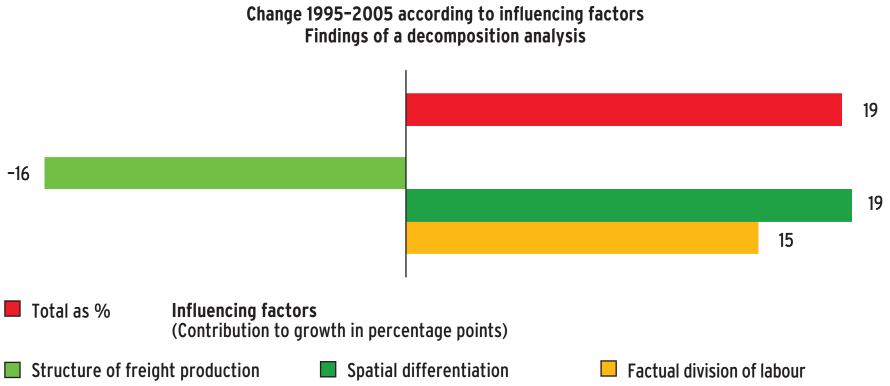
Under its National Sustainability Strategy 2002 the German government has set itself the target of reducing transport intensity by some 5 % for freight traffic and by 20 % for the passenger sector by 2020, compared with 1999 levels. These targets can be met by designing transport systems that meet the needs of the future, by encouraging settlement structures with low traffic densities and regional economic cycles (for the avoidance of traffic) and by improving the efficiency of transport systems.

In 2005 transport intensity in the **passenger** sector was around 96 %, which is just below the base figure for 1999. This shows that the trend of passenger transport is moving in the right direction. However, passenger transport volume is still not sufficiently decoupled from the gross national product.

In recent years freight transport volume has risen at a faster rate than the gross domestic product (GDP), and the **freight transport** intensity has increased to 110 % compared with the 1999 figure. As the current development shows, there is actually a movement away from the desired objective of decoupling. The decoupling of freight transport and economic development has not yet been introduced.

Influences of freight transport on land due to structural factors, intensity and growth (decomposition)

Intensity of domestic freight transport on land



Source: *Federal Statistical Office 2006 (6)*

Freight transport intensity is measured as the domestic freight carrying output (rail and road transport) per gross domestic product (price adjusted). Between 1995 and 2005 it increased by 19 %. This development is the result of various, in some cases opposing, influencing factors.

The change in the division of labour within the economy had an increasing impact on the transport output. The division of labour covers the vertical range of manufacturing by companies. A decreasing vertical manufacturing range is linked with the increase in transport by suppliers domestically and from abroad. An approximate measurement of the division of labour can be achieved using the ratio of total freight volume (goods and services produced domestically and imported) to the gross domestic product. This factor is calculated to contribute by 15 percentage points to the increase in transport intensity.

On the other hand the development of transport intensity was counteracted to the extent of 16 percentage points as a result of the change in the composition of the volume of freight. The change in the structure of demand, with more emphasis on less material-intensive goods, i.e. a greater proportion of services, significant decline in construction activity, and a reduction in the range of transport. The influence of increasing spatial differentiation in production and consumption led to an increase by 19 percentage points. This also reflects the increasing average distance between the production site and the place where the goods are actually used.

The indicator does not take into account the substantial cross-border transport output associated with imports and exports (in the remainder of the world). For example the volume of goods transported by sea via German ports is almost three times higher than that carried domestically.

Land intensity according to production sectors

Settlement area intensity according to production sectors 2004

Source: *Federal Statistical Office 2006 (6)*

Settlement area intensity is defined as the quotient of the settlement area required by an industry and the gross value added attained by this industry. For example if calculations reveal a low settlement area intensity, this means that the industry in question is achieving high gross added value with a small land area. “Agricultural (including forestry and fisheries) products” is a sector with a distinctive characteristic, in which it is not the areas under cultivation but solely the relevant settlement areas that are considered in relation to the gross value added.

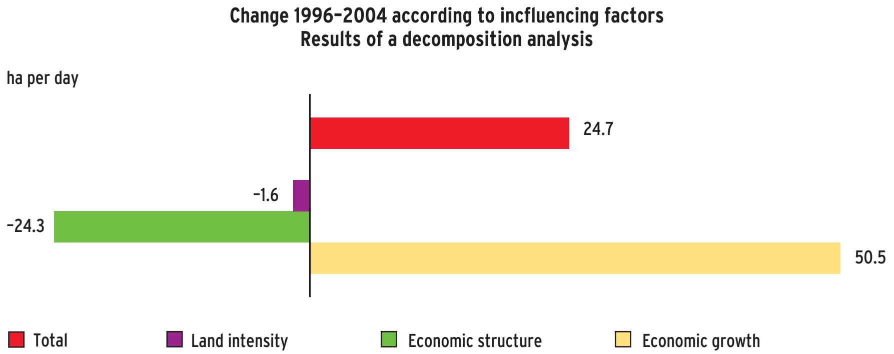
For 2004 the picture is as follows: by far the greatest settlement area intensity is that of the agricultural production sector with 127.9 km^2/bi. EUR. With 6.7 km^2/bi. EUR and 4.0 km^2/bi. EUR respectively the areas of the manufacturing sectors and services operate with a significantly lower land intensity.

In general in 2004 the land intensity figure was 6.8 % lower than in 1996. The decline in the sector of agricultural produce was 4.9 %, and for the manufacturing sectors it was 4.7 %, contrasting with a 3.8 % increase in the land intensity figure in 2004 in the services sector.

In a departure from the general development in the manufacturing sectors, in the sectors of “civil and structural engineering” and “other construction work” there has been a significant increase in land intensity with 41.5 % and 9.1 % respectively. This is due to the fact that the land area used by both of these sectors (– 8.3 %) has not kept pace with a significant downturn in added value in the construction sector (– 26.0 %).

Influences on settlement areas due to structural factors, intensity and growth (decomposition)

Settlement area occupied by production sectors



Source: *Federal Statistical Office 2006 (6)*

Using decomposition analysis the change in the settlement areas occupied by production sectors can be traced back to the following three influencing factors:

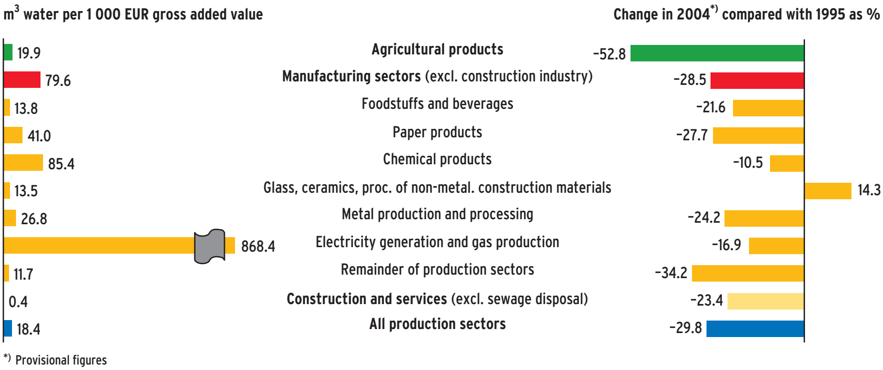
- **Land intensity** – ratio of required settlement area (in km^2) to price adjusted gross value added (in bi. EUR) for each production sector,
- **Economic structure** – the share of the production sectors in the total gross value added,
- **Economic growth** – measured by the sum total of the price-adjusted gross value added of the production sectors.

The amount of settlement land occupied by the production sectors rose during the period under consideration here from 11 274 km^2 (1996) to 11 996 km^2 (2004). If this increase of 721 km^2 or 24.7 ha/day is examined in the light of the aforementioned influencing factors, we obtain the following result:

The decline in settlement area intensity is calculated to produce only a slight reduction over the period in question of 1.6 ha/day (– 45 km^2 or – 0.4 %). A change in the economic structure, favouring less land-intensive sectors, led to a significant decline of 24.3 ha/day (– 709 km^2 or – 6.3 %). On the other hand economic growth is responsible for a theoretical increase in settlement areas of 50.5 ha/day (1 476 km^2 or 13.1 %).

Water intensity according to production sectors

Water intensity according to production sectors 2004



Source: *Federal Statistical Office 2006 (6)*

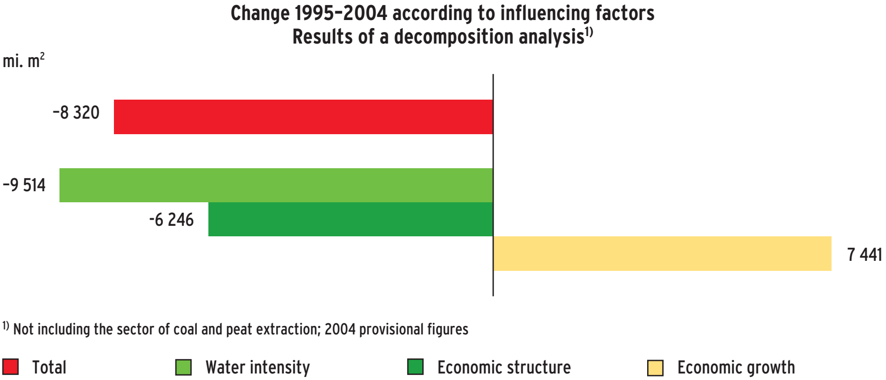
The level of water intensity, measured in terms of the water used per gross value added differs widely in the description of individual production sectors according to technical conditions and the associated demand for water.

Taking the average of all production sectors, in 2004 18.4 m^3 water/thou. EUR gross value added were used. In the manufacturing sector (excluding the construction sector) as a whole the water intensity amounts to 79.6 m^3/thou. EUR. Water intensity is particularly high in the area of “electricity generation and gas production” (868.4 m^3/thou. EUR gross value added). In the case of “chemical products” the water intensity is 85.4 m^3/thou. EUR, for “paper products” it is 41.0 m^3 /thou. EUR and for “metal production and processing” it amounts to 26.8 m^3/thou. EUR gross value added.

Compared with 1995, in 2004 water intensity declined in many production sectors. In the manufacturing sector (excluding the construction sector) water intensity fell by 28.5 %. Within the manufacturing sector the water intensity in the sector of “paper products” fell by 27.7 %, by 21.6 % in “foodstuffs and beverages”, by 24.2 % in “metal production and processing” and by 16.9 % in “electricity generation and gas production”. Internal factors also contributed to the decline in water intensity in the manufacturing sector. In particular there was an increase in the repeat use of water and in recycled water.

Influences on water use due to structural factors, intensity and growth (decomposition)

Water use by production sectors



1) Not including the sector of coal and peat extraction; 2004 provisional figures

Source: *Federal Statistical Office 2006 (6)*

Using decomposition analysis the change in water use by production areas can be traced back to the following three factors:

- **Economic growth** – measured by the sum total of the price-adjusted gross value added of the production sectors,
- **Economic structure** – the share of different areas of the production sectors of the total, price adjusted, gross value added,
- **Water intensity** – The ratio of water used (in m^3) to the real gross yalue added (in EUR). The intensity effect reveals improvements in the efficiency of water use. If water intensity declines over a period of time, this implies more efficient use of the resource water.

Total water use fell by 8 320 mi. m^3 between 1995 and 2004. This development is attributable primarily to a reduction in water intensity throughout the economy as a whole, enabling water savings of 9 514 mi. m^3 to be made. Structural changes in the production sectors have also led to a significant reduction in the water used, amounting to 6 246 mi. m^3. On the other hand economic growth was responsible for an increased demand for water, by 7 441 mi. m^3. Structural and intensity effects have, however, more than cancelled out this increase, with the result that it was possible to substantially reduce the amount of water used.

APPENDIX

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