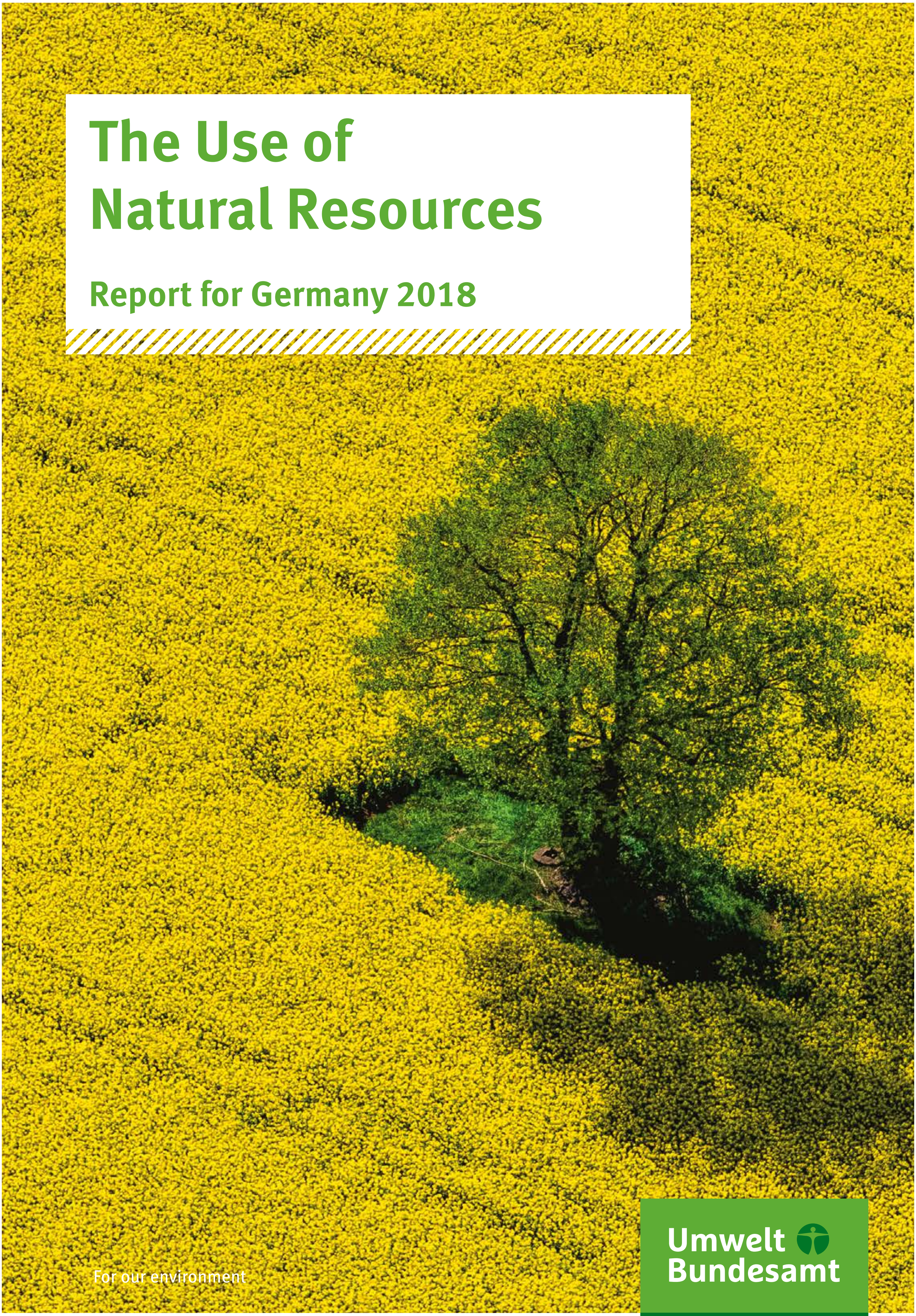
The Use of Natural Resources

Report for Germany 2018



For our environment

Umwelt Bundesamt

Imprint

Publisher:
Federal Environment Agency
Section I 1.1 "Fundamental Aspects, Sustainability Strategies and Scenarios, Sustainable Resource Use"
Postfach 14 06
06844 Dessau-Roßlau
Tel: +49 340-2103-0
info@umweltbundesamt.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt
/umweltbundesamt
/umweltbundesamt

Authors:
Vienna University of Economics and Business (WU) – Institute for Ecological Economics:
Stephan Lutter, Stefan Giljum, Burcu Gözet, Hanspeter Wieland
Federal Environment Agency (UBA):
Christopher Manstein

Translation:
Ursula Lindenberg

Layout:
Gerda Palnmetshofer

Credits:
Cover: cinoby; S. 3: Photostudio D29; S. 12/13: P. AugustovaM;
S. 22/23: silkwayrain; S. 32/33: ThamKC; S. 40/41: Dovapi;
S. 50/51: A. Kazmierski

Order:
Umweltbundesamt
c/o GVP
Postfach 30 03 61, 53183 Bonn
Service-Telefon: 0340 2103-6688
Service-Fax: 0340 2104-6688
E-Mail: uba@broschuerenversand.de
Internet: www.umweltbundesamt.de

This publication as download:
www.umweltbundesamt.de/en/resourcesreport2018

Date: November 2018

ISSN 2363-831X

The Use of Natural Resources

Report for Germany 2018

Foreword

Maria Krautzberger
President of the German Federal Environment Agency

Dear readers,

The International Resource Panel (IRP) of the United Nations reports that in 2017, for the first time ever, more than 90 billion tonnes of natural resources were extracted worldwide. This is three times the amount extracted in 1970. Soil, water, air and raw materials such as metals and non-metallic minerals together form the basis of our everyday life and of our prosperity and wellbeing. However, as both the Earth's human population and economic output increase, not only are ever more resources being used but the competition for these resources is growing as they become scarcer.

Increasing resource consumption is exacerbating global environmental problems such as climate change, soil degradation and the loss of biodiversity. A prolongation of current patterns of production and consumption with a global population reaching nine billion people will lead to a situation in which the natural limits to growth are far exceeded.

In 2012, Germany made a commitment to the conservation of natural resources through the Resource Efficiency Programme (ProgRess). Six years after its adoption, where do we find ourselves in Germany today? The good news is that raw materials use has become more efficient. As compared to international standards, however, Germany still has a high level of raw material consumption at approximately 44 kilogrammes per capita and day. 75% of raw material consumption occurs in the areas of leisure, nutrition and housing.

The German Environment Agency supports the implementation of ProgRess through a range of measures, including the production of this report on the use of natural resources in Germany, which is being published for the second time after the first edition of 2016. This report analyses new data relating to the interlinkage of raw material extraction, trade in raw materials, the role of the economy, and that of consumption. The report also presents specific examples, such as lignite mining and Germany's import dependency in the case of phosphorus.

The topics of water and land use are also explored, as are the links between raw material use and climate change, which are of particular interest. It is evident that the CO_2 footprint and raw material consumption have developed along similar paths over time. This provides further confirmation that resource conservation and climate protection are themes that require a joint approach from policy makers.

I hope this report will provide you with interesting and thought-provoking reading.

Raw material use in Germany – Overview

TRADE

page 22

PHYSICAL TRADE VOLUME

1,040
mio. t

IMPORTS	EXPORTS
DIRECT 642 mio. t	DIRECT 398 mio. t
DIRECT AND INDIRECT (RME) 1,540 mio. t	DIRECT AND INDIRECT (RME) 1,339 mio. t
MONETARY 832 bn. Euro	MONETARY 1,097 bn. Euro

EXTRACTION

page 12

USED DOMESTIC EXTRACTION

1,041
mio. tonnes

ECONOMY

page 32

RAW MATERIAL INPUT (RMI)

2,643
mio. t

MATERIAL CATEGORIES (DMI)	MATERIAL CATEGORIES (RMI)
BIOMASS 396 mio. t	BIOMASS 486 mio. t
NON-METALLIC MINERALS 627 mio. t	NON-METALLIC MINERALS 735 mio. t
FOSSIL FUELS 532 mio. t	FOSSIL FUELS 699 mio. t
METAL ORES 128 mio. t	METAL ORES 723 mio. t

CONSUMPTION

page 40

MATERIAL CATEGORIES	Subcategories
BIOMASS 271 mio. t	Fodder crops 119 mio. t
NON-METALLIC MINERALS 574 mio. t	Boulders 326 mio. t
FOSSIL FUELS 195 mio. t	Lignite 178 mio. t
METAL ORES 0.5 mio. t	

RAW MATERIAL CONSUMPTION (RMC)
1,303 mio. t

FINAL DEMAND-CATEGORIES	CONSUMPTION CATEGORIES
CONSUMPTION 797 mio. t	Private households 76 percent
BUILDINGS 629 mio. t	State 19 percent
INVESTMENTS 107 mio. t	NGOs 5 percent
CHANGES OF STOCK -229 mio. t	

OTHER RESOURCES

page 50

DIRECT WATER USE 25.1 bn. m³	WATER FOOTPRINT 225.6 bn. m³
AGRICULTURAL LAND 184,332 km²	LAND FOOTPRINT 223,580 km²
PRIMARY-ENERGY CONSUMPTION 13,262 petajoule	SHARE OF RENEWABLE ENERGIES IN PRIMARY ENERGY CONSUMPTION 12.4 percent
CO_2 EMISSIONS 907 mio. t	CARBON FOOTPRINT 913 mio. t

Content

Key figures 8
Methodological background 10

Glossary 62
Data tables 65
References 73
List of figures and tables 75

Domestic raw material extraction 12

Domestic extraction: Non-renewable raw materials 14
Domestic extraction: Renewable raw materials 16
Raw material extraction by the federal states 18
Domestic extraction: The example of lignite 20

Germany's share in global raw material trade 22

Direct imports and exports 24
Indirect imports and exports 26
The geographical origin of raw materials 28
International interdependencies:
The example of phosphorus 30

The role of the economy ↘ 32

Raw material input in the economy ↘ 34
Development of raw material productivity ↘ 36
Circular economy in Germany ↘ 38

Raw materials for consumption ↘ 40

Composition and trends of final demand ↘ 42
Public and private consumption ↘ 44
Raw material consumption by consumption areas:
The example of food ↘ 46
Raw material consumption by consumption areas:
The example of health ↘ 48

Other natural resources ↘ 50

Water use and water footprint ↘ 52
Land use in Germany ↘ 54
Germany's land footprint ↘ 56
Flow resources ↘ 58
Raw material use and climate change ↘ 60

Key figures

28

page 12

Domestic raw material extraction
In 2015, 1,040 million tonnes of non-renewable and renewable raw materials were mined, excavated or harvested in Germany. Although this represents an overall reduction since 1994, extraction of renewable raw materials increased by **28 %**. Today, these are used not only in foodstuffs but increasingly also as fuels and construction materials as well as in the pharmaceutical industry.

243

page 22

Germany's share in global raw material trade
Germany is a trading nation. Goods are imported, further processed, and a significant proportion is then re-exported. While in 2015 Germany imported **243 million tonnes** more goods than it exported, at the same time it generated a monetary trade surplus of **265 billion Euro**. The manufacture of higher-value products increases the value per tonne and thus the value added.

58

page 32

The role of the economy

In 2014, about **58 %** of the raw materials processed in the German economy were non-domestic in origin. This includes those raw materials that were required along the value chain beyond Germany's national borders in order to produce the traded goods. By comparison: in 2000 this share comprised 55 %, while by 2010 it was as high as 61 %.

16.1

page 40

Raw materials for consumption

Raw material consumption (RMC) of German final demand comprises all raw materials that are required along the supply chains of goods and services. In 2014, the per-capita figure was **16.1 tonnes**, with an absolute amount of 1.3 billion tonnes. Although this represented a reduction since 2000, when the per-capita figure was 18.5 tonnes, it has increased again in recent years.

31.5

page 50

Other natural resources

In 2015, the share of renewable energies in gross electricity consumption already stood at **31.5%**. This represents a significant increase since 1990, where the share was no higher than 3.4 %. Flow resources constitute an important alternative to fossil fuels and make a vital contribution to climate and resource protection.

Methodological background

Natural resources and the focus of the resource report 2018

Natural resources comprise all components of nature. These include renewable (biotic) and non-renewable (abiotic) raw materials, physical space, area/land, environmental media, i.e. water, soil and air, flow resources, and all living organisms. This report focuses on the analysis of data relating to the extraction of raw materials from the environment, i.e. materials such as biomass, fossil energy sources, non-metallic minerals and metal ores. The report also considers the subsequent use of these raw materials in the economic system, i.e. their processing into semi-finished and finished products, trade and final use in Germany. A separate chapter deals with other natural resources, such as water or land.

What is the purpose of analysing data on raw material use?

Raw materials form an important basis for the functioning of our economy and satisfying our needs. However, the Earth's reserves of non-renewable resources are finite. In addition, the extraction of raw materials is connected to a large number of negative environmental impacts. Because of this, developing robust indicators for the interpretation of raw material use has become increasingly important in recent years. The aim is to achieve a better understanding of which raw materials and what quantities of those materials are required for particular economic activities, and where these originate. The analysis of data and the interpretation of these indicators hold particular relevance for three areas: (1) scientific policy advice and the development of concrete policy measures, (2) the economically and environmentally sustainable management of raw material use, and (3) the identification of further research needs.

Data sources for direct raw material use

In Germany, the Federal Statistical Office (Destatis) collects data on raw material use in the framework of environmental-economic accounts (EEA) – analogous to the system of national accounts, which depicts the monetary flows within an economy. Data on raw material use are published by Destatis in varying degrees of detail and comprise up to 35 raw material groups. The most recent raw material data currently available through the EEA refer to 2015. In the context of the EEA, Destatis also records so-called unused extraction i.e. the quantities of material that have to be moved to obtain access to the raw materials used (e.g. overburden or harvest residues). However, since the availability of data at international level is not satisfactory, the OECD, for example, no longer reports official figures for unused material extraction, and the Statistical Office of the EU (Eurostat) has removed this category from its official methodological handbook.

How can we determine the ways in which these raw materials are used?

Destatis compiles so-called input-output tables, which depict the economic interdependencies between production and consumption in a very detailed form, expressed as monetary values (i.e. in Euro). This enables to identify which economic sectors exchange products and the role played by final demand. Extracted raw materials are recorded in physical units (i.e. tonnes) and then assigned to those sectors that are responsible for their extraction – for example, non-metallic minerals to the mining sector, wood to the forestry sector, etc. By looking at the economic inter-dependencies in monetary terms, raw material inputs can be related to specific supply chains and to final demand. Tracing physical raw material flows through monetary data can produce inaccuracies, for which reason "hybrid" forms of input-output tables are increasingly used, in which monetary values are partly replaced by physical values.

Harmonising methods accounting for international trade

To provide a comprehensive depiction and analysis of raw material use in Germany, it is essential not only to look at those raw materials that are extracted within Germany's borders but also to consider those that are extracted and used along the international trade and production chains involved in creating the products consumed or further processed in Germany.

In the last ten years, various methodological approaches have been developed for quantifying raw material consumption at the national level (Lutter et al. 2016a). These include (1) approaches based on input-output models (see above), (2) those based on coefficients that record the resource intensity of individual goods, and (3) so-called "hybrid" approaches, i.e. a combination of both approaches. These three options can also be applied to other resource categories (e.g. water or land), allowing for the quantification of overall resource use.

Since these different models often produce varying results, international initiatives aimed at harmonising calculation methods have been underway for some time. The most prominent of these is coordinated by the OECD, which works together with Eurostat, the Statistics Division of the United Nations (UNSD) and a number of national statistical offices, such as Destatis, to improve international harmonisation regarding data sources and methods.

Data sources for indirect use of raw materials

This report draws upon two sources for data on indirect raw material flows. The first of these is Destatis, which calculates raw material consumption for Germany on the basis of a hybrid input-output calculation model.
The results provided by this model are currently available for the period from 2010 to 2014 (and in an earlier version, for 2000–2010). These are used for all Germany-specific analyses. The second data source is the model EXIOBASE 3.3, (www.exiobase.eu; Stadler et al. 2018), which is based on a global input-output analysis. EXIOBASE was developed in the context of European research projects and is characterised by its high level of detail. The model distinguishes 200 product groups, 49 countries and country groups and currently provides data for a time series from 1995–2014.

Due to differences in the underlying methodologies, the figures from Destatis tend to produce lower results than those based upon the EXIOBASE calculations, and thus the two are not directly comparable. Results from the EXIOBASE calculations are therefore used in this report primarily for analyses regarding the structure of international supply chains and for international comparisons.

The water footprint concept and its role in the resource report 2018

The total volume of water that is used domestically as well as internationally for the production of all goods consumed within a country is defined as the "water footprint" (Hoekstra et al. 2009). It consists of a "blue water" component (surface and ground water) and a "green water" component (rainwater). Often, additionally the "grey water" footprint is calculated, which is defined as the hypothetical water volume required to dilute polluted water. Grey water is not included in this report.

Similarly to the indirect use of raw materials, the water footprint can also be calculated using coefficients or models based on input-output tables. The most well-known approach is that developed by the founder of the water footprint concept, A. Y. Hoekstra (Hoekstra et al. 2009), which uses coefficients. However, in the resource reports for Germany the EXIOBASE model is applied because of its methodological advantages and for reasons of data availability and comparability (cf. description above; Stadler et al. 2018; Lutter et al. 2016b).

Base year for the resource report 2018

This report uses data from the most recent environmental accounts provided by Destatis regarding used and unused raw material extraction and direct trade. The most recent year for which data is available in this context is 2015. However, relating to indirect raw material flows, Destatis data is only available up to 2014. This is also the case regarding international comparisons for indirect raw material flows, for which the EXIOBASE model is used. Data on water use from the EEA is only available up to 2013, and water footprint calculations only exist up to 2011. Land footprint data is available up to 2010.

Changes since the previous report

The present report is the second in the resource report series. The UBA Resource Report 2016 contained descriptions of the main general interrelationships. Some aspects will therefore not be set out in renewed detail here, referencing the previous report. The figures presented in the current report are not directly comparable with those of the UBA Resource Report 2016. There are various reasons for this.
In December 2017, Destatis published a new version of environmental-economic accounts (EEA), which not only contained an additional reporting year (2015) but also reported altered values for previous years. Alongside this, in March 2018 Destatis published an updated estimate for material uses in raw material equivalents (i.e. direct and indirect raw material quantities). The new figures cover the period 2010-2014, but are not directly comparable with earlier published data from Destatis because they were produced on the basis of different, revised versions of the system of national accounts (SNA). Finally, the multiregional input-output model EXIOBASE has also undergone further development. Version 3.3 now contains not only a complete times series for the years 1995–2014 but also corrected figures for trade and environmental data (available at www.exiobase.eu).

Domestic raw material extraction

1,103
mio. tonnes
+4.2 %

1,041
mio. tonnes
-5.6 %

Used domestic extraction
2014 and 2015, change from the previous year

13.6
tonnes
+3.8 %

12.7
tonnes
-6.4 %

Used domestic extraction per capita
2014 and 2015, change from the previous year

2,024
mio. tonnes
-0.9 %

2,007
mio. tonnes
-0.8 %

Unused domestic extraction
2014 and 2015, change from the previous year

207
mio. tonnes

178
mio. tonnes

Used domestic extraction of lignite
1994 and 2015

Federal state with lowest/highest per-capita extraction 2015

Saarland

3.2
tonnes

Saxony-Anhalt

30
tonnes

799 mio. tonnes -0.1 %

769 mio. tonnes -3.7 %

Used extraction of non-renewable raw materials
2014 and 2015, change from the previous year

72 percent

74 percent

Share of non-renewable raw materials in used domestic extraction
2014 and 2015

304 mio. tonnes +16.8 %

271 mio. tonnes -10.7 %

Used extraction of renewable raw materials
2014 and 2015, change from the previous year

28 percent

26 percent

Share of renewable raw materials in extraction
2015

Changes in used domestic extraction
1994–2015

-31 percent

Non-renewable raw materials

+28 percent

Renewable raw materials

Data sources: page 77

Domestic extraction: Non-renewable raw materials

In Germany in 2015, 1,041 million tonnes of non-renewable and renewable raw materials were extracted from nature. This represents 12.7 tonnes per capita and year, or 35 kilogrammes per capita and day. After a sharp increase in 2014, total extraction has returned to the long-term declining trend. At approximately 770 million tonnes, non-renewable raw materials constitute roughly three quarters of total extraction.

In 2015, the domestic extraction of non-renewable and renewable raw materials in Germany amounted to 1,041 million tonnes. This represented a decrease from 2014 (1,103 million tonnes) of around 6%. Of the total extraction, about 74% comprised non-renewable and 26% renewable raw materials.

During the period 2011–2013, total domestic extraction showed a 5% reduction. While it increased significantly from 2013–2014 – the first such increase in three years – the lower figure for 2015 shows a return to the long-term trend. The significant increase in 2014 was largely attributable to the increasing extraction of renewable raw materials. In comparison, during 2015, both renewable and non-renewable raw material extraction decreased to a similar extent (around 30 million tonnes).

Non-metallic minerals constitute the largest share of total extraction and amount to 574 million tonnes (↘ Fig. 1), followed by biomass, fossil fuels, and metal ores. The latter play a minor role, since they are almost entirely imported (↘ pp. 26/27, “Direct imports and exports”).

Non-renewable raw materials are divided into three major groups: fossil fuels, non-metallic minerals and metal ores. In the economy, these are used as construction materials, energy sources or basic materials, e.g. for chemical products or machinery. Where non-metallic minerals are concerned, the sub-group of construction minerals forms the largest share, at 517 million tonnes, followed by industrial minerals at 58 million tonnes (↘ Fig. 2). It is evident that the decrease in extraction of non-renewable raw materials by 29.5 million tonnes between 2014 and 2015 largely occurred in the area of construction minerals, with a reduction by around 25 million tonnes. About one-quarter of total extraction of non-renewable raw materials in 2015 concerned fossil fuels, 91% of which was lignite (↘ pp. 20/21, “The example of lignite”).

The extraction of non-renewable raw materials in Germany shows a long-term downward trend. In the period from 1994 to 2015, it decreased by almost one-third (31%), from 1,122 million tonnes to only 769 million tonnes (↘ Fig. 3). Estimates by the UN Environment International Resource Panel see a similar trend for Germany during the period 1970-2015 (UN IRP 2017). The reason for this is, on one hand, that the demand for new infrastructure after German re-unification was extremely high. This level of demand and construction activity generally declined, and consequently the demand for non-metallic minerals. On the other hand, this reflects the decreasing importance of lignite (↘ pp. 20/21, “The example of lignite”).

Used raw material extraction in Germany, 2015

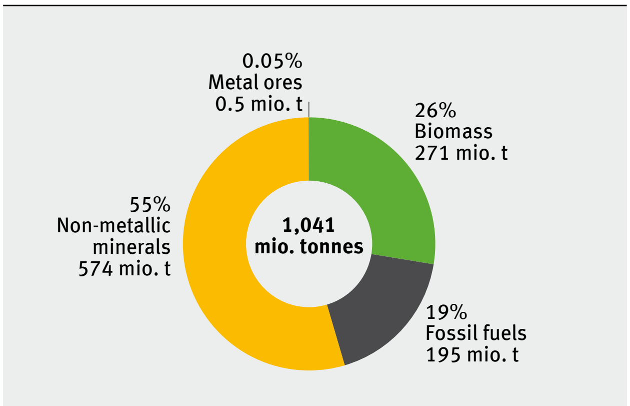


Figure 1 Source: Destatis, 2017 a

Used extraction of non-renewable raw materials in Germany, 2015

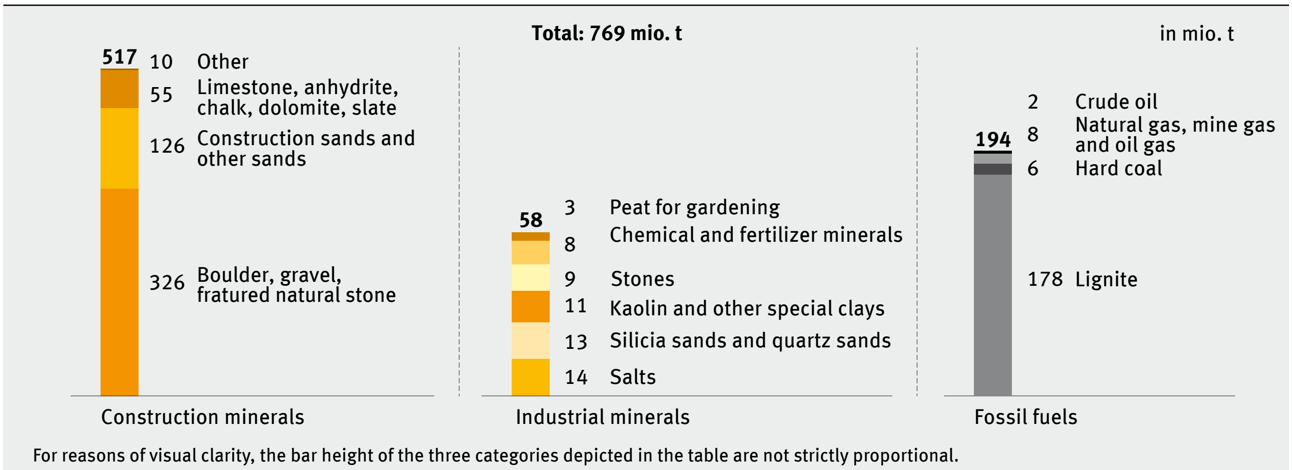


Figure 2 Source: Destatis, 2017 a

Development of used extraction of non-renewable raw materials in Germany, 1994–2015

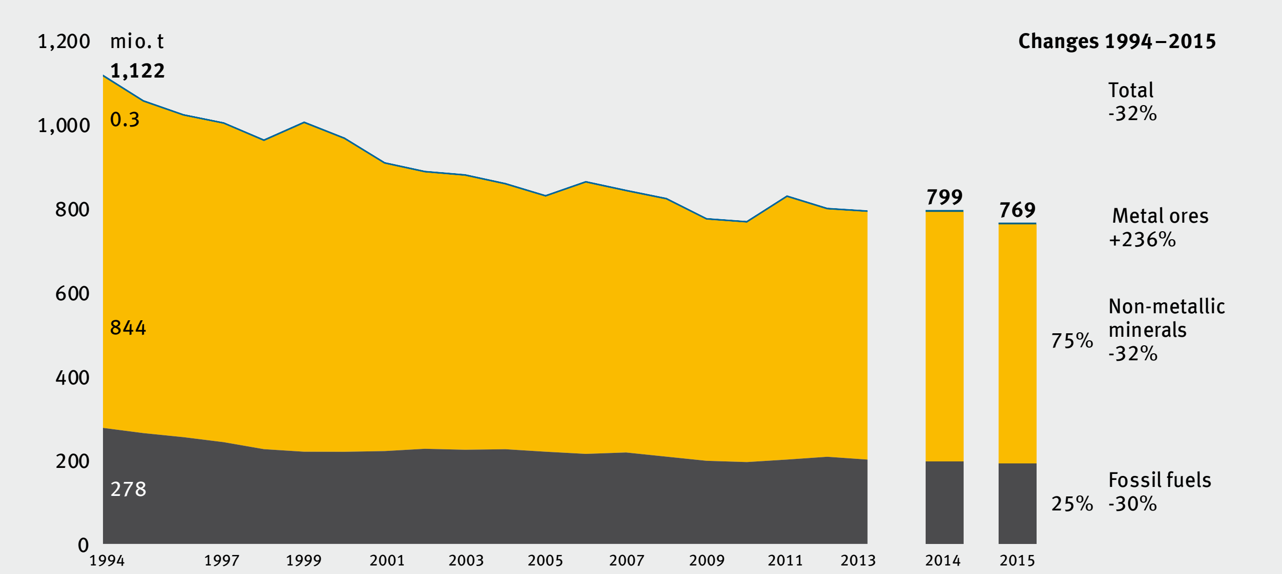


Figure 3 Source: Destatis, 2017 a

A detailed analysis of developments over the last two decades makes clear that the extraction of individual raw materials has undergone significant fluctuations (➘ Fig. 4).

For instance, the extraction of crude oil rose by 29 % in the period to 2003, reaching its peak at 3.8 million tonnes, before beginning a continuous decline. In 2015, crude oil extraction was 2.4 million tonnes, about 82 % of the value for 1994. However, it is hard coal that shows the starkest decline during the period considered here, during which extraction decreased by 88 %. Subsidies for hard coal mining in Germany are scheduled to come to an end completely in 2018 (Deutsche Bundesregierung, 2007).

Trends of the extraction of individual sub-categories of fossil fuels (left) and mineral raw materials (right) in Germany, 1994–2015

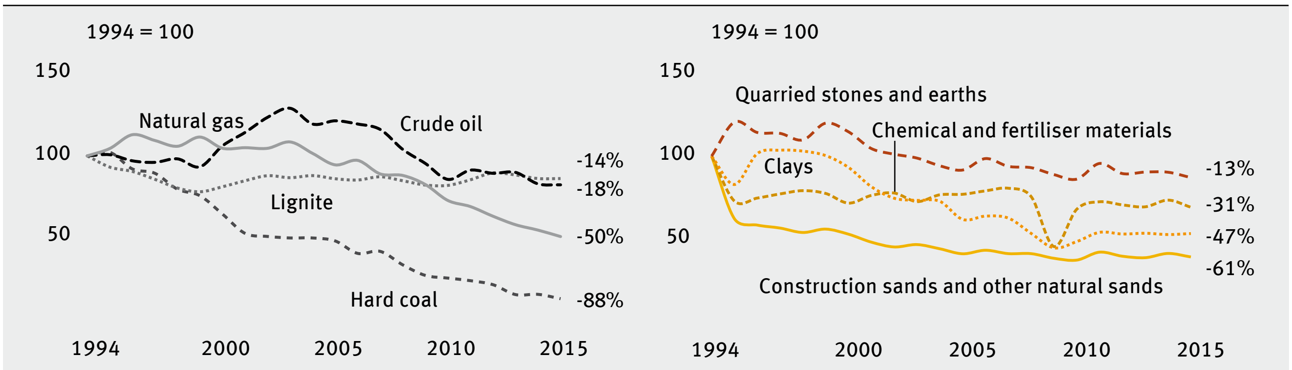


Figure 4 Source: Destatis, 2017 a

Unused extraction

The extraction of raw materials involves the displacement of large quantities of materials, which cannot be exploited economically. In 2015, this so-called unused extraction, at more than two billion tonnes, represented almost double the quantity of used extraction (Destatis, 2017 b). The overburden from lignite mining constituted by far the largest share, almost 80 %, of total unused extraction (➘ pp. 20/21, “The example of lignite”). Unused biomass, such as harvest residues from agriculture and forestry, and bycatch from the fishing industry made up a further 9 % of the total unused extraction. Excavated earth for construction and civil engineering and tailings from mineral extraction constituted 6 % and 5 % respectively. It is evident that since 1994 the absolute quantity of unused extraction decreased as did used extraction, and the average ratio of unused to used extraction was 1.9. While this ratio was only 1.6 in 1997, it reached 2.1 and thus its highest level in 2010. The extraction quantity of unused materials highlights the enormous impact that humans have upon the environment, which can lead to significant consequences for society and ecosystems. These include, for example, the loss of habitats and landscapes, and overfishing in maritime environments.

Domestic extraction: Renewable raw materials

Renewable raw materials comprise raw materials from agriculture and forestry as well as those from fishing and hunting. They include fruit and vegetables, cereals, wood or fish. In 2015, 271 million tonnes of renewable raw materials were extracted in Germany. In contrast to non-renewable raw materials, the long-term trend of the extraction of renewable raw materials in Germany shows a significant increase of 28 % since 1994. A particularly significant increase of 17 % was recorded between 2013 and 2014.

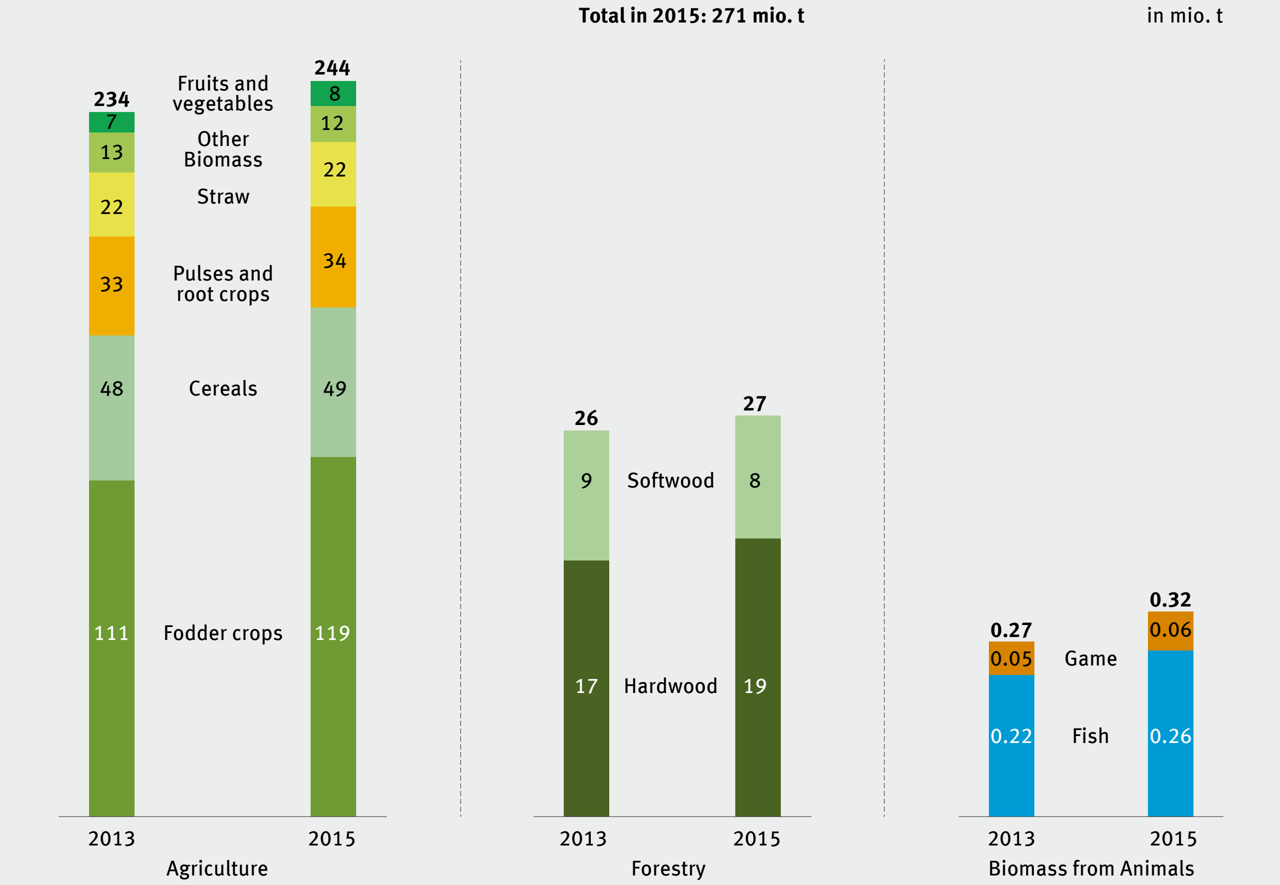
In 2015, 271 million tonnes of renewable raw materials were extracted in Germany. Agriculture accounted for 90 % and thus by far the greatest proportion of domestic extraction of renewable raw materials (↘ Fig. 5). Extraction by forestry (coniferous and non-coniferous wood) stood at about 27 million tonnes or 10 % of the total and thus played a far less significant role.

While the total extraction of renewable raw materials rose by 17 % in the period 2013–2014 alone, it fell back again by 11 % between 2014 and 2015. Increases in the extraction of nearly all renewable raw materials can be seen for the period 2013–2015, the reporting year of the UBA Resource Report 2016. The most significant of these in quantitative terms was the growth in the category of fodder crops and grassland (7 %; 8 million tonnes), followed by cereals (2 %; 1 million tonnes) and fruits and vegetables (9 %; 700,000 tonnes).

The significant share of fodder crops and grassland, comprising about 49 % of total domestic extraction of renewable raw materials, reflects the key influence of livestock farming in Germany. Fodder crops and grassland serve partly to provide food for 47 million laying hens, 28 million pigs, almost 13 million beef cattle and one and a half million sheep which, together with the 287,000 tonnes of animal products from the hunting and fishing sectors, ensure food supplies for the human population as well as the production of products for export (Destatis 2015, a).

In the long term too, domestic extraction of renewable raw materials shows a significant increase – 28 % since 1994 (↘ Fig. 6). This growth trend is evident for all sub-categories of renewable raw materials. However, the increase in fodder crops is particularly noticeable, with extraction rising by 41 % to almost 119 million tonnes. This represented 44 % of total extracted biomass in 2015.

Used extraction of renewable raw materials in Germany, 2013 and 2015



"Fodder crops and grassland" – These comprise renewable resources that can be extracted from meadows, grazing or cut pastureland, alpine pastures, rough pasture and haymeadows. For reasons of visual clarity, the bar height of the three categories depicted in the figure is not strictly proportional.

Figure 5

Source: Destatis, 2017 a

Trend of extraction of renewable raw materials in Germany, 1994–2015

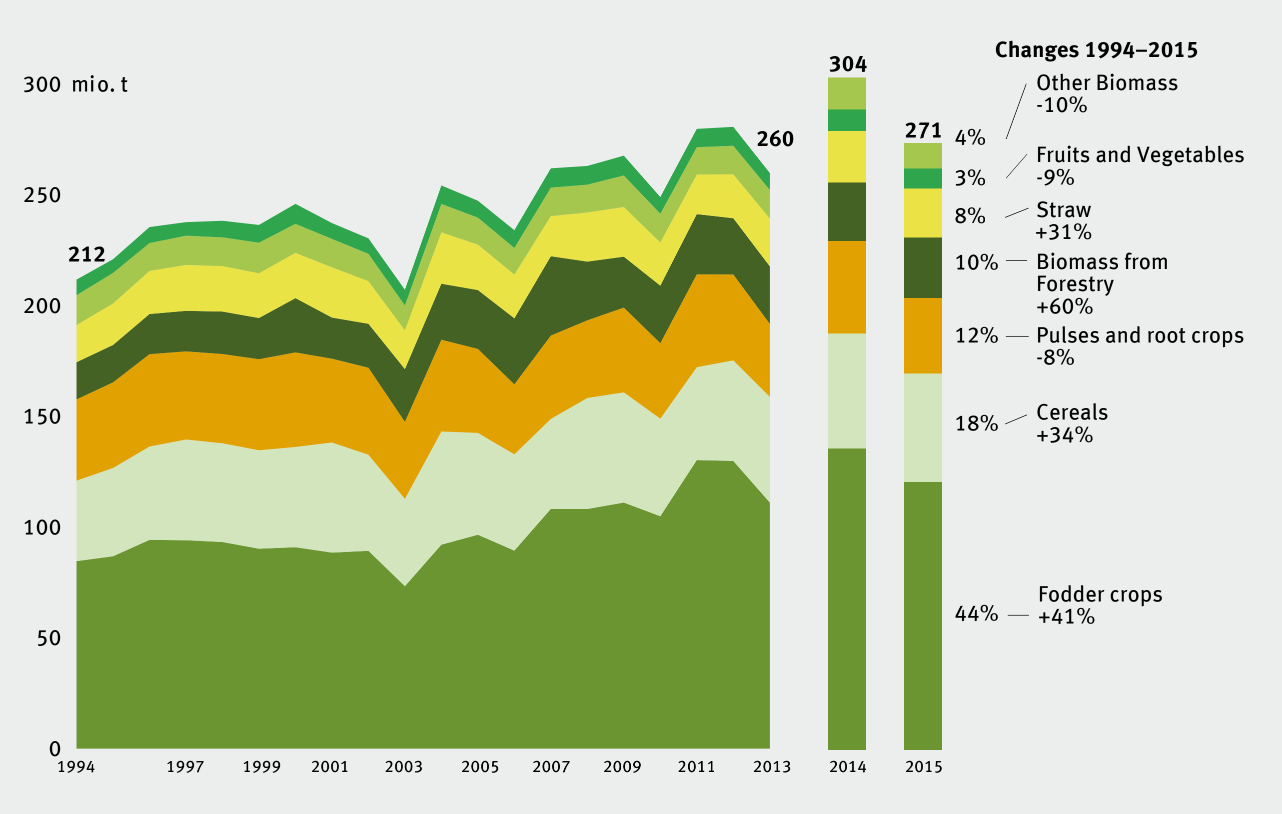


Figure 6 Source: Destatis, 2017 a

Looking at the trend of the quantitatively most important sub-categories of renewable raw materials (↘ Fig. 7), it is evident that the extraction of coniferous (hard wood) and non-coniferous (softwood) wood showed the largest increase during the period 1994–2015, increasing by 60 %. A significant rise in 2007 can be attributed to the winter storm 'Kyrill' (→ p. 19, UBA Resource Report 2016). Along with the already mentioned considerable increase in the extraction of fodder crops, yields of cereals also rose by 35 % during the period observed. Only roots and tubers showed a slight decrease (-9 %), albeit with marked fluctuations.

The increasing use of biomass in Germany can also be attributed to the fact that renewable raw materials are increasingly being used in production processes. They find employment not only as energy sources but also in their material use as a promising alternative to fossil fuels, e.g. as the basis for plastics and chemicals. This trend, however, has an impact on global land use. For example, arable land is used not only for fodder and feed production but also for agrofuels. In many cases, this leads to direct competition (↘ pp. 56/57, "Germany's land footprint").

Trends of extraction of individual sub-categories of renewable raw materials in Germany, 1994–2015

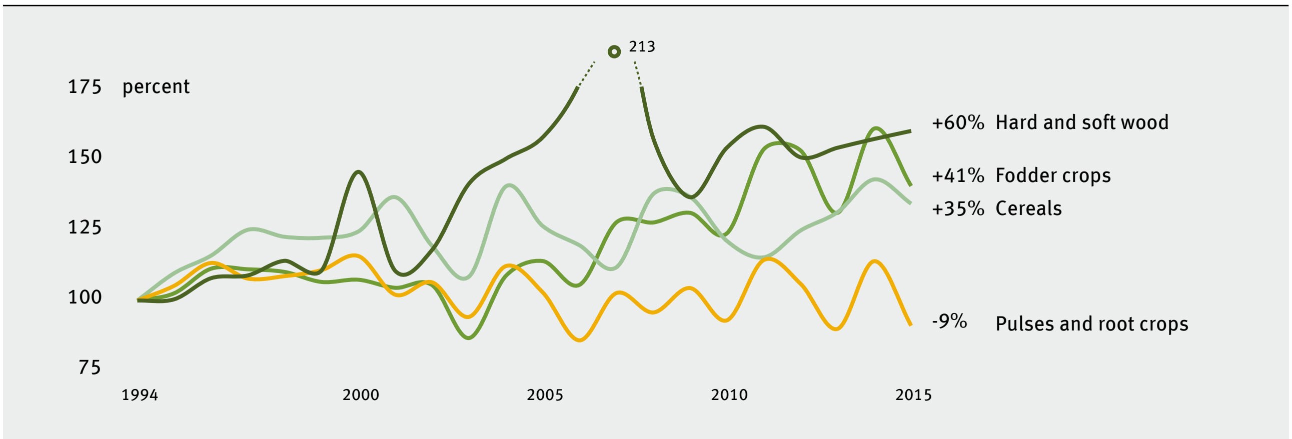


Figure 7 Source: Destatis, 2017 a

Raw material extraction by the federal states

Raw materials extraction is very unevenly distributed across the federal states in Germany. In absolute terms, extraction is concentrated within a few of the larger federal states. Almost a quarter (243 million tonnes) of total domestic extraction took place in North Rhine-Westphalia. The per-capita perspective produces an entirely different picture, however. Given its high population density, North Rhine-Westphalia was actually below the average federal per-capita extraction figure of 13.7 tonnes in 2015. With the exception of Schleswig-Holstein, all federal states show evidence of a decrease in extraction between 1994 and 2015.

The individual federal states vary greatly with regard to extraction of non-renewable and renewable raw materials. For example, North Rhine-Westphalia (NRW) was the largest extractor of raw materials in Germany in 2015, extracting more than 243 million tonnes. The same state was also the largest extractor of non-renewable raw materials – 215 million tonnes. Lower Saxony was the largest producer of renewable raw materials, harvesting 60 million tonnes. In contrast, Saarland only extracted three million tonnes in total (↘ Fig. 8).

Essentially, almost every federal state extracts raw materials from all three categories – non-metallic minerals, fossil fuels and biomass. Particularly large quantities of non-metallic minerals are mined in North Rhine-Westphalia (113 million tonnes), Bavaria (102 million tonnes) and Baden-Württemberg (82 million tonnes). Fossil fuesls are extracted in particular in North Rhine-Westphalia (102 million tonnes), Saxony (40 million tonnes) and Brandenburg (33 million tonnes). Biomass plays a role in all the federal states.

The quantity and type of raw materials extracted in each federal state are determined by a number of factors. Along with the significant factor of the size of individual federal states, it is primarily geological aspects that determine the availability of non-renewable raw materials. Further to this, accessibility and settlement density also play a role in determining how many raw materials can be extracted in which federal state.

Where renewable raw materials are concerned, area availability, soil quality and management practices are determining factors. The GDP of respective federal states is also a key factor, as is the economic importance of raw material sectors in individual federal states. All these elements must be taken into account when comparing absolute extraction figures for the individual federal states.

Per-capita approaches are more meaningful than a comparison of absolute figures, since this perspective allows to put the very large variation in extraction quantities into perspective. North Rhine-Westphalia, Germany's largest extractor of raw materials in absolute figures, had a per-capita extraction of 13.7 tonnes – below the states' average. At 30 tonnes per person, Saxony-Anhalt took pole position from the per-capita perspective in 2015, closely followed by Brandenburg at 29.2 tonnes per capita. Saarland showed the lowest figure at 3.2 tonnes per capita.

In line with the national trend, raw material extraction increased significantly in almost all federal states between 2013 and 2014, and decreased remarkedly between 2014 and 2015. In many cases, extraction actually fell below the level of 2013. This was the case in Baden-Württemberg, Brandenburg, North Rhine-Westphalia and Thuringia. However, in some states, particularly those of quantitative importance, extraction of renewable raw materials rose significantly between 2013 and 2015; for example, in Bavaria or Saxony. These developments also reflect the trend for Germany as a whole, not only can 2014 be seen as anomalous, but also the importance of renewable raw materials increased steadily (↖ pp. 16/17, "Renewable raw materials").

Between 1994 and 2015, raw material extraction decreased in all federal states apart from Schleswig-Holstein. Saarland reduced its extraction by almost 80 % or 11.4 million tonnes due to a cessation of hard coal mining. The largest reduction in terms of quantity, 76.9 million tonnes, was recorded in North Rhine-Westphalia. This represents 24% of the extraction from 1994.

Concerning the extraction of non-metallic minerals, there was a reduction in almost all the federal states on a scale of 30% on average. Particularly noteworthy are Saarland and – more significant in quantitative terms –

Development of used raw material extraction and shares of the three major categories in the German federal states, 1994 and 2015

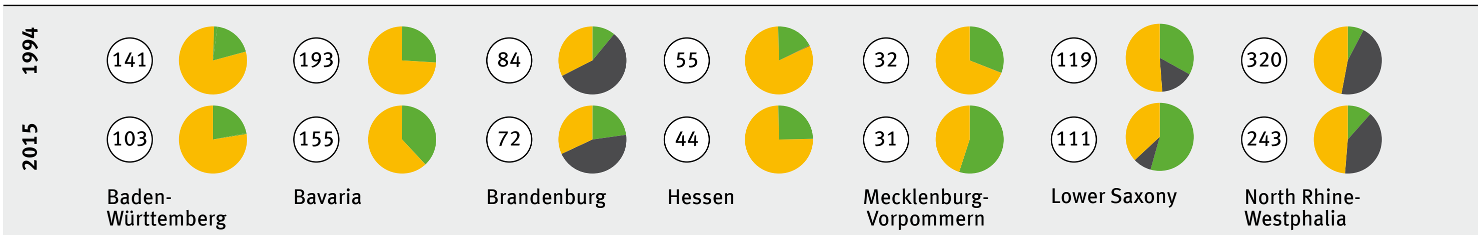


Figure 9

Used raw material extraction in the German federal states, 2015

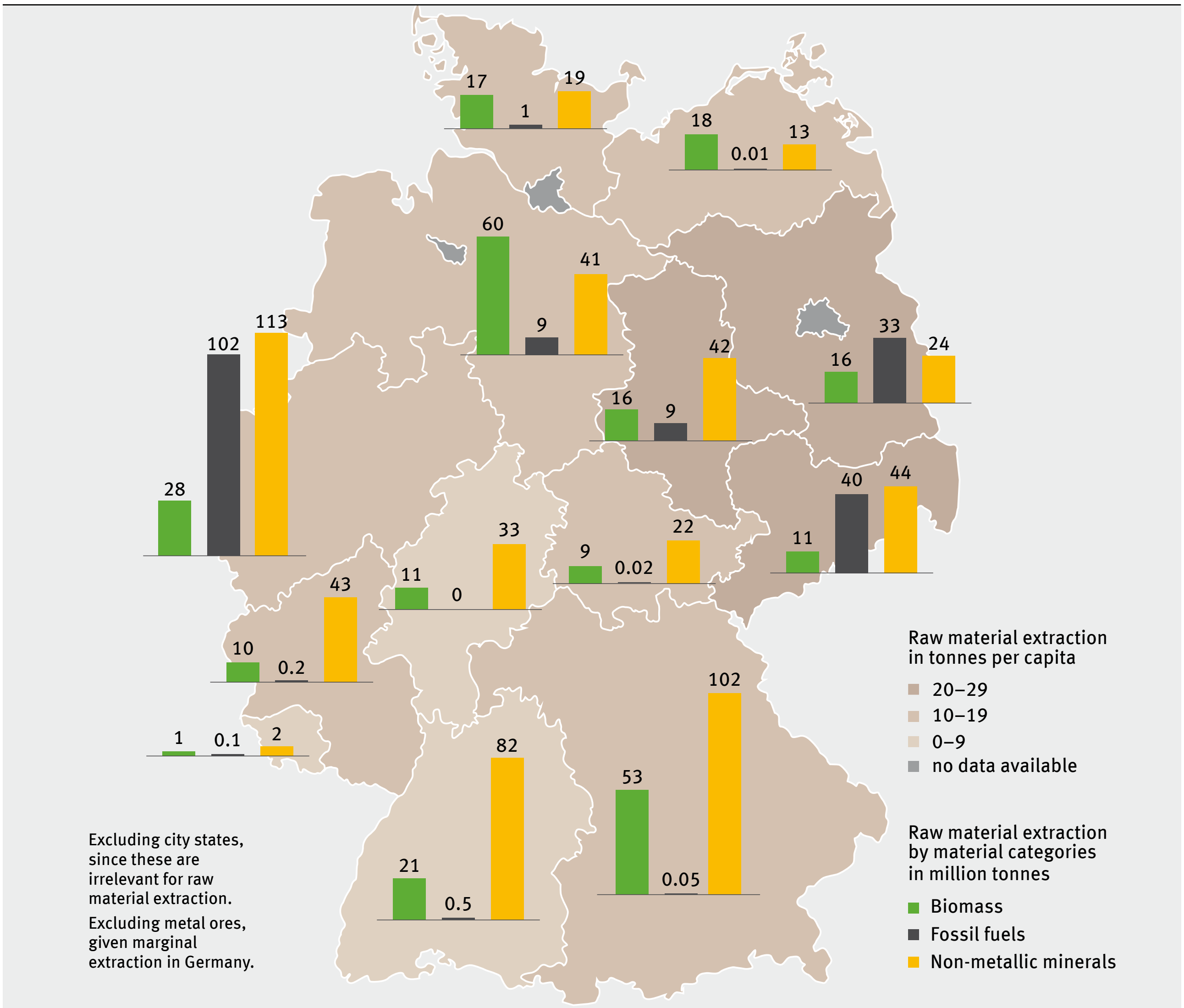


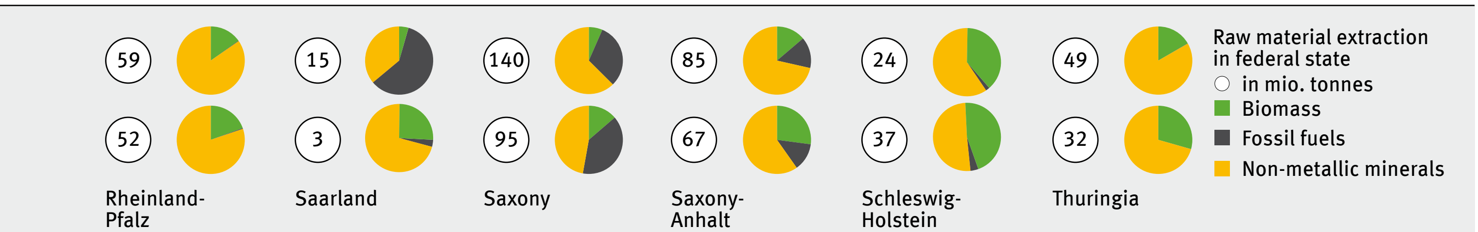
Figure 8

Source: Statistische Ämter der Länder, 2017

Saxony, with an above-average reduction of 57 % and 50 % respectively, and Schleswig-Holstein, as the only federal state to record an increase (30 %).

The extraction of fossil fuels decreased sharply in the individual federal states. Bavaria, Mecklenburg-Vorpommern, Saarland and Thuringia reduced their extraction by at least 70 %, and in Hessen extraction ceased completely. Only in the cases of Rheinland-Pfalz and Schleswig-Holstein could an increase of the very low level of extraction be observed. In absolute values, however, the three large-scale producers, North Rhine-Westphalia, Saxony and Brandenburg remained at the top of the table, despite their decreasing trend in fossil fuel extraction (Fig. 9).

With the exception of Saarland, there was a marked increase in extraction of renewable raw materials in all the federal states. This was particularly significant in the cases of Mecklenburg-Vorpommern and Schleswig-Holstein, where extraction increased by more than 80 % over the last 20 years.



Source: Statistische Ämter der Länder, 2017

Domestic extraction: The example of lignite

Since the very beginning of industrial production, Germany has occupied the first place world-wide in the extraction of lignite. In 2015, more than 178 million tonnes of lignite were mined in Germany. As an important source of energy, it currently supplies about one-quarter of gross electricity production. In Germany, lignite is the only fossil energy feedstock that is available in large quantities and therefore rarely imported. In global terms, lignite plays only a minor role, being responsible for 1.3 % of primary energy consumption worldwide.

The fossil energy carrier lignite is a significant component of raw material extraction in Germany. 178 million tonnes of lignite were extracted in 2015. After the group "Boulders, gravel and natural stone" (↖ Fig. 2, p. 14), lignite is the second most important raw material extracted in Germany in quantitative terms. It represents a 17 % share of total domestic raw material extraction (↘ Fig. 10). When considering the group of non-renewable raw materials (769 million tonnes), lignite represented a quantitative share of 23 %. Within the group of fossil energy carriers extracted in Germany (195 million t), lignite dominated with a share of over 91 % (↘ pp. 14/15, "Non-renewable raw materials", ↘ pp. 16/17, "Renewable raw materials").

Lignite mining in Germany decreased sharply in the period 1994–2015. In 1994, 207 million tonnes were produced. In 2010 this figure was the lowest to date, at 169 million tonnes. Despite a slight increase to 178 million tonnes in 2015, lignite mining decreased overall from 1994 by 14 % (↘ Fig. 11).

In Germany, lignite is primarily used for the production of electricity in baseload power plants. Although the share of lignite in German gross energy production fell slightly after 1994 (by four percentage points), it was still as high as 24 % in 2015. In comparison, lignite accounted for approximately one half of German primary energy consumption. It decreased slightly after 1994 and comprised 12 % of the total in 2015. This figure was almost double even at the beginning of the 1990s. Increasing use of oil has been the primary cause of lignite's decreasing importance as an energy carrier (BMWI, 2017).

In global terms, lignite – in contrast to hard coal – plays a rather minor role. Its share in worldwide primary energy consumption was around 1.3 % in 2013 (UBA, 2015 a). However, Germany is the world's largest producer of lignite (responsible for around 19 % of global extraction in 2014). In international terms, China took second place in 2015, producing about 145 million tonnes of lignite (16 %), followed by Russia, with 73 million tonnes (8 %) (UN IRP, 2017).

The most important active lignite mining regions in Germany are in the Rhineland, in Lausitz, in central Germany and in Helmstedt. The Rhineland region was responsible for the largest volume of lignite extraction, producing 95 million tonnes in 2014. The second most important region was Lausitz, producing 62 million tonnes (Statistik der Kohlenwirtscchaft e. V., 2017). Lignite reserves located in Germany are estimated to comprise about 40 billion tonnes. Internationally, Germany possesses the third-largest reserves, behind Russia and Australia (UBA, 2015 a).

The extraction and use of lignite is linked to significant environmental damage. Indeed, lignite pro-duces the greatest climate and environmental impact of all fossil fuels. 172 million tonnes of energy-related CO_2 emissions in Germany were caused by the burning of lignite in 2015. This figure was only exceeded by that related to mineral oil products (246 million tonnes). Where electricity production was concerned, lignite was by far the greatest cause of

Share of lignite in total used raw material extraction in Germany, 2015

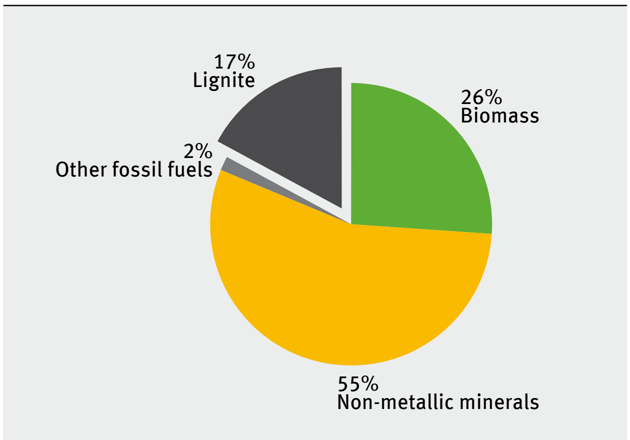


Figure 10 Source: Destatis, 2017 a

Trends of lignite mining in Germany, 1994–2015

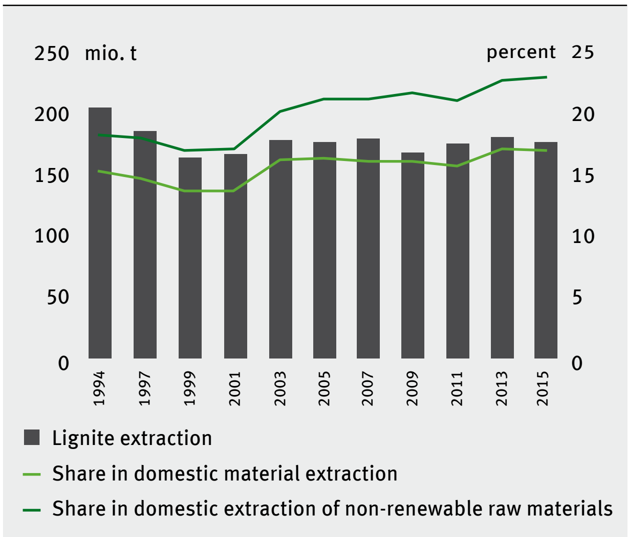


Figure 11 Source: Destatis, 2017 a

Selected data on the use of lignite in Germany, 2015

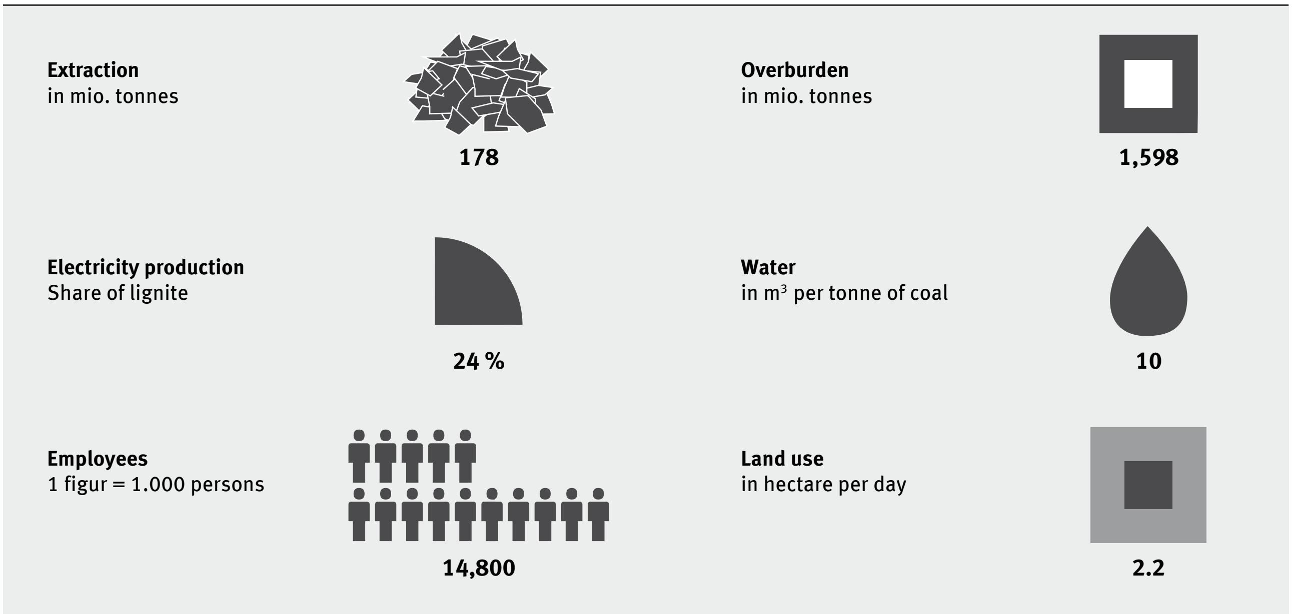


Figure 12 Sources: Destatis, 2017 a; UBA, 2015 a; Statistik der Kohlenwirtschaft e. V., 2017

CO_2 emissions and was responsible for about 50% of all emissions (BMWI, 2017). Alongside CO_2 emissions, lignite burning also involves the release of further pollutants that impact on air, water and soil quality (⇢ pp. 64/65, UBA Resource Report 2016).

Lignite extraction involves mining processes that require the groundwater level to be significantly lowered (by up to 400 m). During mining activities for each tonne of lignite on average 10 cubic metres of water must be removed. This equates to 10 tonnes of water for each tonne of lignite (↘ Fig. 12; UBA, 2015 a).

To gain access to lignite deposits through surface mining, strata need to be removed in huge quantities, with negative impacts for the landscape, among other factors. In Germany, per tonne of lignite extracted, between 6 and 9 cubic metres of this overburden have to be excavated as unused extraction (⇢ pp. 22/23, UBA Resource Report 2016) (UBA, 2015 a). This represents about 8 to 12 tonnes for each tonne of lignite extracted (Destatis, 2017 a). Part of this overburden is utilized for landscaping during recultivation.

Although the overall quantity of overburden decreased between 1994 and 2014 from 1,870 to 1,598 million tonnes, the area being utilized for surface mining actually increased. In 1994, an area of 151,000 hectares was used for lignite mining. By 2015, this figure had risen to 176,500 hectares. Nonetheless, the share of recultivated land, which can be used once again for forestry, agriculture or other purposes, also increased over time and comprised 69% of the entire area subject to mining activities by 2015 (Statistik der Kohlenwirtschaft e. V., 2017).

Cessation of Lignite Mining in Germany

Significantly reducing the use of fossil energy sources, and particularly the environmentally damaging use of coal, is a key aspect of effective climate protection. As part of a transformation process to ensure that ambitious targets for climate protection are met in Germany – particularly a reduction in greenhouse gas emissions by 95% (from 1990) – coal-based electricity generation needs to be curtailed dramatically, alongside other measures (UBA, 2017 a). The German Environment Agency recommends that from 2020, electricity generation by hard coal and lignite power plants aged 20 years or older should be limited to 4,000 full-load hours per year. In addition, five gigawatts produced by the oldest or least efficient of the lignite power plants should be removed from the grid by 2020, above and beyond the planned shutdowns. A further recommendation from the German Environment Agency involves the additional closure of coal power plants to achieve a remaining maximum total capacity of 19 gigawatts by 2030.

Germany's share in global raw material trade

1,040 mio. tonnes +3.8 %

Physical trade volume
2015, change from the previous year

642 mio. tonnes +3.4 %

Physical imports
2015, change from the previous year

398 mio. tonnes +4.6 %

Physical exports
2015, change from the previous year

265 bn. Euro +13.3 %

Monetary export surplus
2015

243 mio. tonnes +1.5 %

Physical import surplus
2015, change from the previous year

38 percent

Share of direct imports in material input (DMI)
2015

50 percent

Share of direct imports in material consumption (DMC)
2015

61 percent | 58 percent

Share of direct and indirect imports (RME) in raw material input (RMI)
2010 and 2014

+18 percent

Relationship of direct and indirect imports (RME) to raw material consumption (RMC)
2014

31 percent

Share of domestic raw material extraction that flows directly and indirectly into the production of exports
2014

1,601 mio. tonnes | 1,540 mio. tonnes

Direct and indirect imports (RME)
2010 and 2014

1,330 mio. tonnes | 1,399 mio. tonnes

Direct and indirect exports (RME)
2010 and 2014

Data sources: page 77

Direct imports and exports

In 2015, Germany achieved a monetary trade surplus of 265 billion Euro. This trade surplus is, however, not reflected in the physical trade balance. Considering physical material flows, 642 million tonnes of imports contrast with an export total of only 398 million tonnes. This disparity highlights the important role of trade and the manufacturing industry for the German economy, which imports material-intensive goods, while exporting higher-value goods.

In 2015, in addition to domestic extraction amounting to 1,041 million tonnes (pp. 14/15, "Domestic extraction"), a further 642 million tonnes of raw materials, semi-finished products and finished products were imported into Germany (Fig. 13). Imports involved in particular those raw materials not found in Germany as well as raw materials or goods that can be produced more cheaply outside the country. In comparison to 2013 (pp. 26/27, UBA Resource Report 2016), direct imports rose by 6%. Direct export volumes rose after 2013 by even 8 % and reached a volume of 398 million tonnes by 2015.

Comparing the physical and the monetary trade balances, the growing significance of global trade for Germany becomes visible. In 2015, Germany's industrial sector exported goods and raw materials worth more than 1,097 billion Euro, while spending no more than 832 billion Euro on imports. This created a monetary export surplus of 265 billion Euro, representing a 21% increase from the export surplus of 2013.

The physical trade balance exhibits contrary trends to the monetary trade balance and reveals a higher import volume (Fig. 13). In 2015, the import surplus comprised 243 million tonnes. This represents an increase of 4% compared with 2013. This disparity between the physical and monetary trade balance can be explained by the fact that the traded raw materials and goods are imported and exported at different stages of processing and thus also at different prices. More than half of all physical imports in 2015 were raw materials (355 million tonnes), of which fossil fuels comprised the largest trade flow by far (244 million tonnes). Semi-finished and finished goods each amounted to one-fifth of imports. Key among finished goods were products derived from metal ores, e.g. sheet metal, steel girders, automobiles etc., and those from biomass, such as food products.

In contrast to imports, Germany exported primarily finished and semi-finished goods in 2015. Only 23% of exports comprised raw materials. Goods based on metal ores, such as vehicles or machinery, and biomass (wood) as well as oil-based products, such as pharmaceuticals, formed the dominant share of finished products. In other words, Germany's exports have a higher value per kilogramme than the country's imports.

Looking at the long-term trend, a development becomes evident that is typical for a national economy, which increasingly specialises in the manufacturing and service industries (Fig. 14). Between 1994 and 2015, physical imports of raw materials and semi-finished and finished goods rose by 39%. This represents an average yearly growth rate of 1.6%. The most marked increase concerned imports of biomass-based products (+76%). Where exports are concerned, there was an increase of 78% (on average 2.8% per year), of which exports of products based on biomass and fossil fuels increased most, doubling in each case. By comparison, monetary imports and exports increased much more rapidly. Imports rose by 5.5% and exports by as much as 5.9% annually.

Germany's direct trade flows in physical and monetary terms in 2013 and 2015

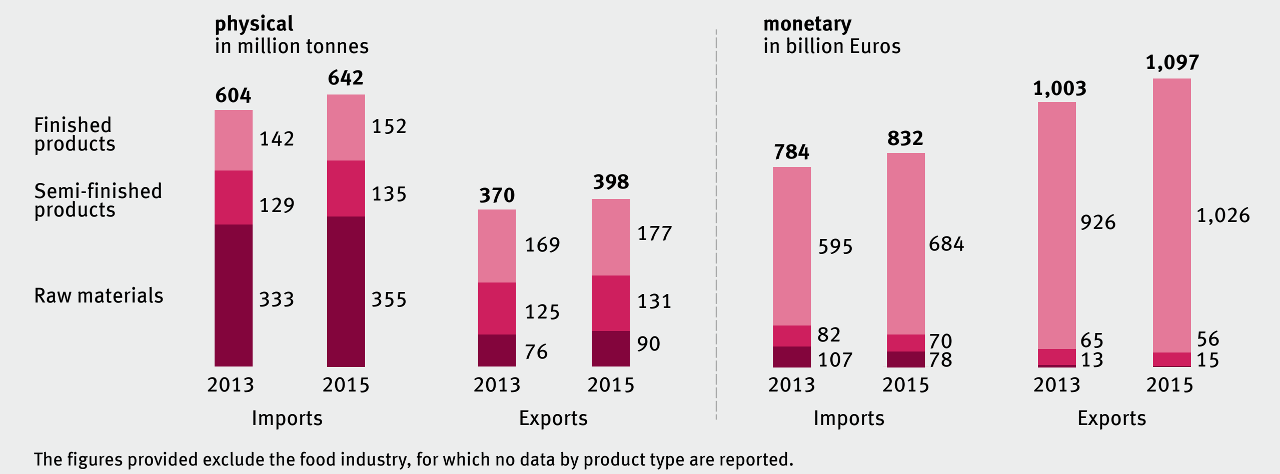


Figure 13

Sources: Destatis, 2017c

Development of direct imports and exports in Germany – monetary and physical, by main category, 1994–2015

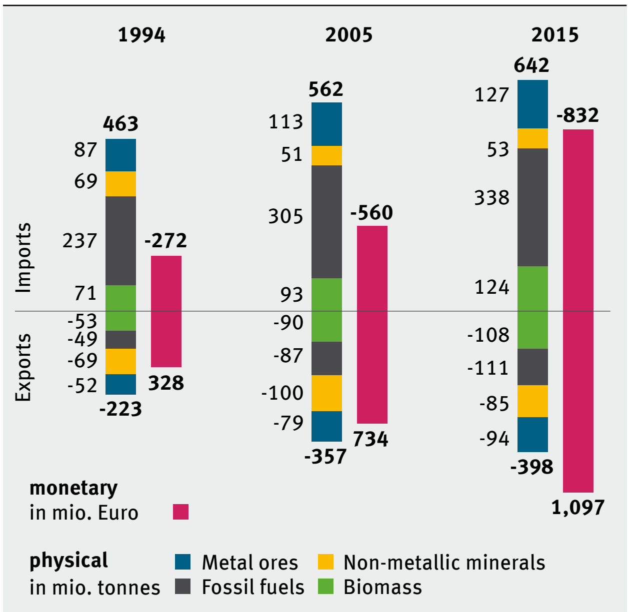


Figure 14 Sources: Destatis, 2017 a, 2017 c

While the absolute physical trade surplus remained roughly constant, the monetary trade surplus quadrupled during the same time period (1994–2015). Figure 14 highlights the fact that in relation to its imports, Germany managed to export more goods with a lower weight, but which had higher value added.

Germany's trading partners include numerous large industrialised countries but also some that are less developed, which act primarily as suppliers of raw materials. The major trading partners – measured in terms of monetary trade volumes – are China, France and the Netherlands.

A clear disparity between the traded monetary values for raw materials and goods and their physical weight is evident in the case of most of Germany's trading partners (Fig. 15). This difference is most noticeable in the case of China, to which 8 million tonnes with a value of 71 billion Euro were exported and from where 12 million tonnes with a value of 92 billion Euro were imported. A similar picture emerges in trade with Russia. In 2015, 92 million tonnes of raw materials and goods with a value of 30 billion Euro were imported, in contrast to 3 million tonnes of exports, which, however, had a value of 22 billion Euro.

In terms both of the physical and monetary trade balance, the Netherlands was by far the most important trade partner in 2015. This is because Rotterdam is the most important port in Europe. Because of this special status, the Netherlands is actually among the few industrialised countries that show a positive monetary trade balance with Germany. Other examples for these are emerging economies, including China, Russia and Indonesia.

In 2015, Germany's monetary trade volume was the third largest in the world, after China and the USA. While Germany traded in raw materials and goods with a value of 2,386 billion Euro, the trading volumes of the other two countries were about 4,000 billion Euro in each case. In comparison with 2013, the trade volume of Germany had fallen by 10%, while those of China and the USA fell by 5% and 2% respectively. This represents a break in the growth trend observed between 2002 and 2014.

Regardless of the size of a country's economy and its trading volume, a significant slump in trade was observed in all countries following the global economic crisis of 2008. This crisis had a sustained impact that continues to the present day, since the growth rate of trade in recent years has failed to return to the level seen between 2001 and 2008.

Comparison between physical and monetary trade balances of Germany with selected countries, and the development of their trade volumes, 2015

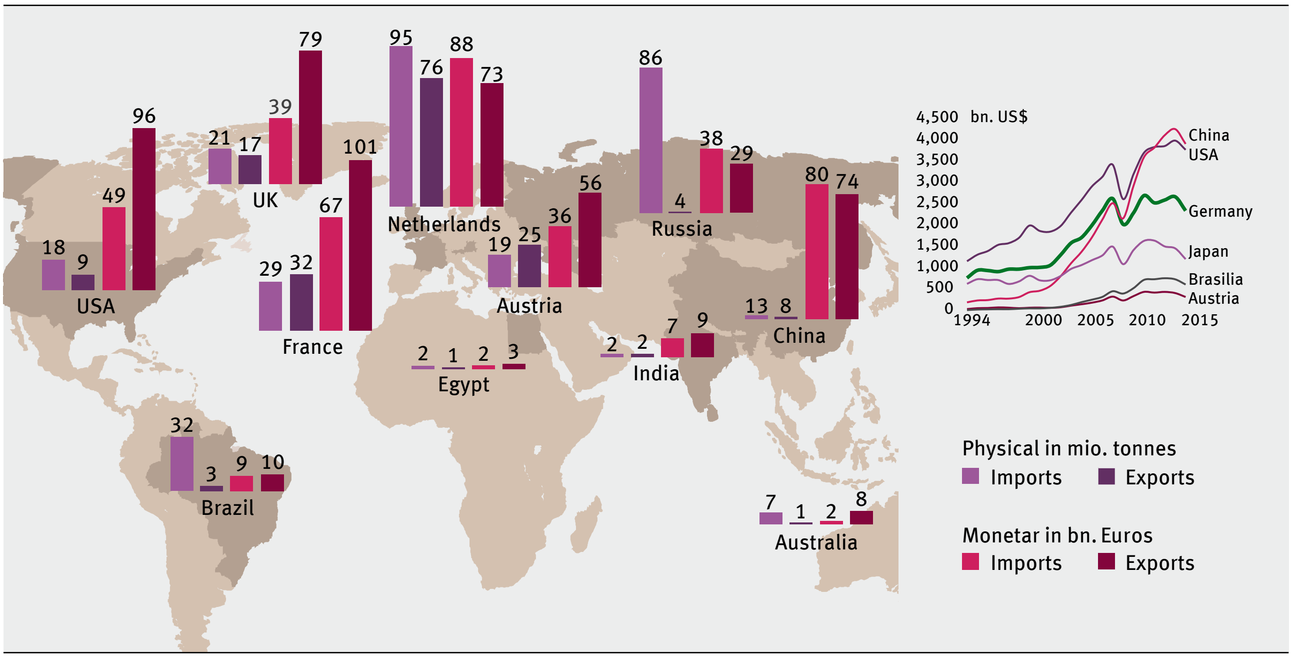


Figure 15 Sources: Destatis, 2017 c, 2017 d

Indirect imports and exports

All semi-finished and finished goods imported into Germany contain indirect raw material flows – those raw materials that are used as inputs along international supply chains. When these indirect flows are accounted for, Germany's physical trade volumes increase by almost a factor of 3. Indirect raw material flows increased sharply in the past and comprised 919 million tonnes in imports alone by 2014. Considering indirect imports and exports also displays a clear import surplus of 201 million tonnes. This shows that production and consumption are increasingly dependent particularly on foreign inputs.

Economic globalisation also means that production chains are increasingly organised at the international level. In the context of this increasing interdependency of the global economic system, taking account of indirect raw material flows is particularly important. When calculating so-called raw material equivalents (RMEs), the direct flows are converted into the quantities of all those raw materials that are input along the entire supply chain of individual traded products and services. Thus, for example, in the case of an excavator, all the raw materials that are required for the production of tyres, shovels, the windscreen, etc. are quantified.

In contrast to the 621 million tonnes of direct imports for 2014 (↖ pp. 24/25, "Direct Imports and Exports"), the total of direct and indirect raw material imports amounted to 1,540 million tonnes and thus constituted 2.5 times the former amount. In the case of exports, the RMEs were also significantly higher (by a factor of 3.5) and amounted to 1,339 million tonnes (↘ Fig. 16). On principle, the indirect raw material flows are significantly higher than the direct flows, since far more than simply the actual weight of products is included in the calculations.

Comparison of actual weight versus raw material equivalents for Germany's imports and exports, 2014

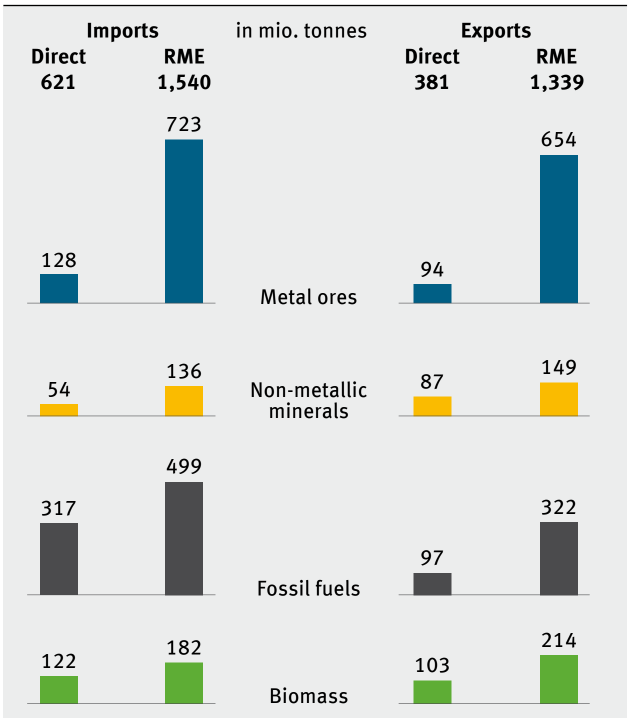


Figure 16 Source: Destatis, 2018

Looking at the period between the reference year for the UBA Resource Report 2016 (2011) and the current reference year 2014, the RMEs for imports and exports have decreased, despite the fact that direct imports and exports rose within the same time period (→ pp. 28/29, UBA Resource Report 2016). While direct flows increased in each case by 1%, the RMEs fell by 8% in the case of imports and 5% in the case of exports. This shows that during the last four years the share of indirect flows for both imports and exports fell. The decrease in indirect flows was slowed due to a striking increase in indirect biomass flows for imports and exports, by more than a quarter in each case.

In long-term trends, however, RMEs rose significantly. For example, the RMEs for imports in the period from 2000 to 2014 rose by 14%, while those of exports rose by as much as 32% (↖ Fig. 16). For imports and exports, the increase in RMEs for biomass is noteworthy again, in each case roughly doubling over the period. Fossil fuels also showed a similar increasing trend for imports and exports (20%). Where metal ores and non-metallic minerals are concerned, the RMEs for exports rose considerably (25% and 20% respectively), while those for imports remained more or less unchanged.

It is striking that, in contrast to recent years, the relationship between direct flows and RMEs for imports and exports in the period from 2000 to 2014 remained almost unchanged, i.e. they increased at roughly the same rate.

It is also noteworthy that this relationship in the case of exports (a factor of 3.5) was much higher than in the case of imports (a factor of 2.5). The reasons for these developments can be diverse and are linked to the composition of imports and exports and to their domestic use. A precise analysis at such a highly aggregated level is difficult and requires an investigation of the supply chain structure in relation to the individual raw materials used both abroad and domestically.

Imported raw materials and the finished products manufactured from them are in part delivered directly to the domestic final demand. These are largely finished products that undergo no further transformative process in Germany, such as, for example, vehicles produced in other countries or mobile telephones. Another share of imported raw materials flow into further processing in individual sectors of the German industry. These further processed products then

Development of Germany's direct and indirect raw material imports and exports, 2000 – 2014

* The values for 2000 are based on an earlier revision of the national accounts and are thus not directly comparable with those for 2011 and 2014.

Figure 17 Sources: Destatis 2017 a, 2018

serve either to meet domestic final demand or are exported once again as semi-finished or finished products with increased value added. The scale of further processing for domestic consumption or export – and thus the quantity of RMEs associated with this – varies according to raw material category (↖ Fig. 18). In 2014, about 76 % of total biomass from domestic extraction or imports flowed into German final demand. The remaining 24 % was supplied to meet the demand for so-called intermediate goods (13 %) or final demand (11 %) abroad. There is a completely different pattern in the category of metal ores. In 2014, around 49 % of the metals, almost 100 % of which were imported from abroad, flowed into domestic final demand, while a significant share (36 %) was accounted for by the export of intermediate goods. This demonstrates the important role of Germany as an exporter of machinery and other manufactured goods, which predominantly contain metallic raw materials. Around 15 % of the metals used had foreign final demand as their end destination, for example in the form of exported vehicles.

Direct and indirect raw material flows through the German economy, by category of raw material, 2014

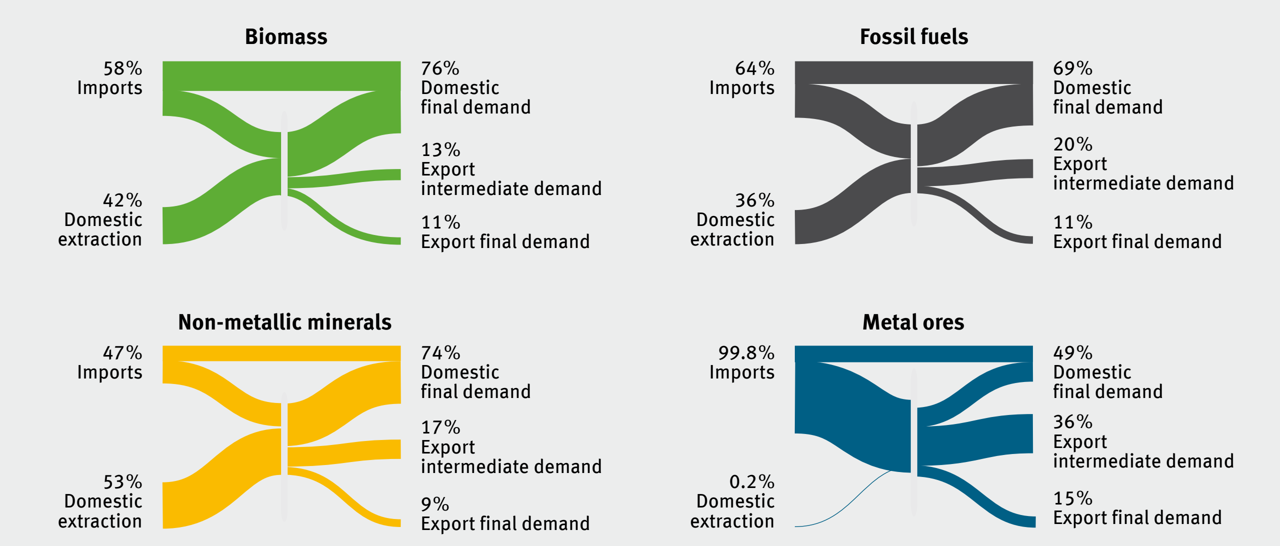


Figure 18 Source: WU, 2017 a

The geographical origin of raw materials

In 2014, 58 % of raw materials that were used in Germany for the production of goods came from abroad. The majority of these were contained in inputs into imported products or services performed outside the country. Direct and indirect raw material imports are highly relevant both for domestic consumption and for the export sector. Import dependencies of this kind play an important role with regard to the supply security of a country and highlight the responsibility for production conditions along global value chains.

The goods consumed in Germany or further processed for export are based on raw materials that originate in all parts of the world. Depending on the product or raw material group, the share of raw materials from domestic extraction and those from imports varies in the total quantity, which was input along the individual value chains (known as “raw material input” or RMI). This lies in the fact that the stocks and accessibility of raw materials and their resulting supply chains vary greatly depending on geographical factors. Using economy-environment models allows for the origin of raw materials to be traced and quantified (↖ pp. 10/11, “Methodological background“).

While the share of raw materials originating abroad in total RMI in 2014 was 58 %, in the case of metal ores this figure was 100 %, since Germany has almost no ore deposits or none for which extraction is economically viable. In the case of fossil fuels, the share was 71 %, for that of biomass 37 % and in the case of non-metallic minerals only 19 % (↘ Fig. 19).

Share of imports in raw material inputs (RMI) in Germany by raw material group, 2014

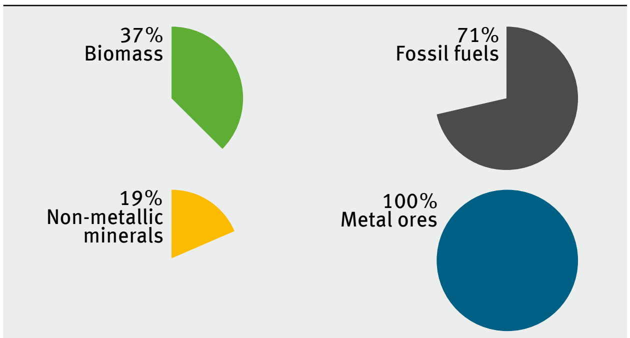


Figure 19 Source: Destatis 2018

Looking at the share of individual raw materials from domestic or foreign extraction (↘ Fig. 20), it becomes clear that on one hand, for some raw materials, the inputs from abroad play only a minor role. Examples include sand and gravel (7 %) or lignite (9 %). On the other hand,

Domestic and foreign share of raw material inputs (RMI) for Germany, by primary raw materials, 2014

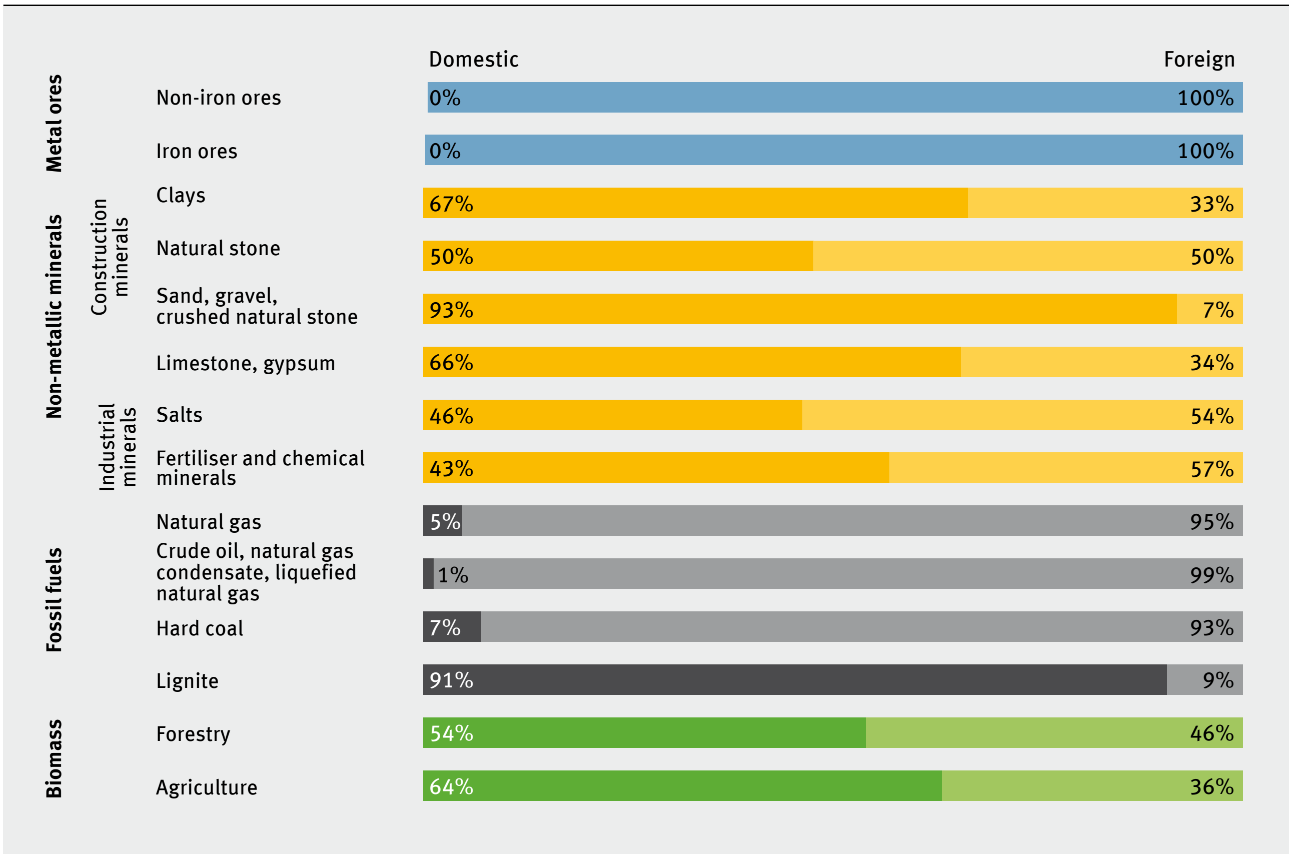


Figure 20 Source: Destatis 2018

Geographical origin of Germany's raw material consumption (RMC) by raw material group and world region, 1995–2014

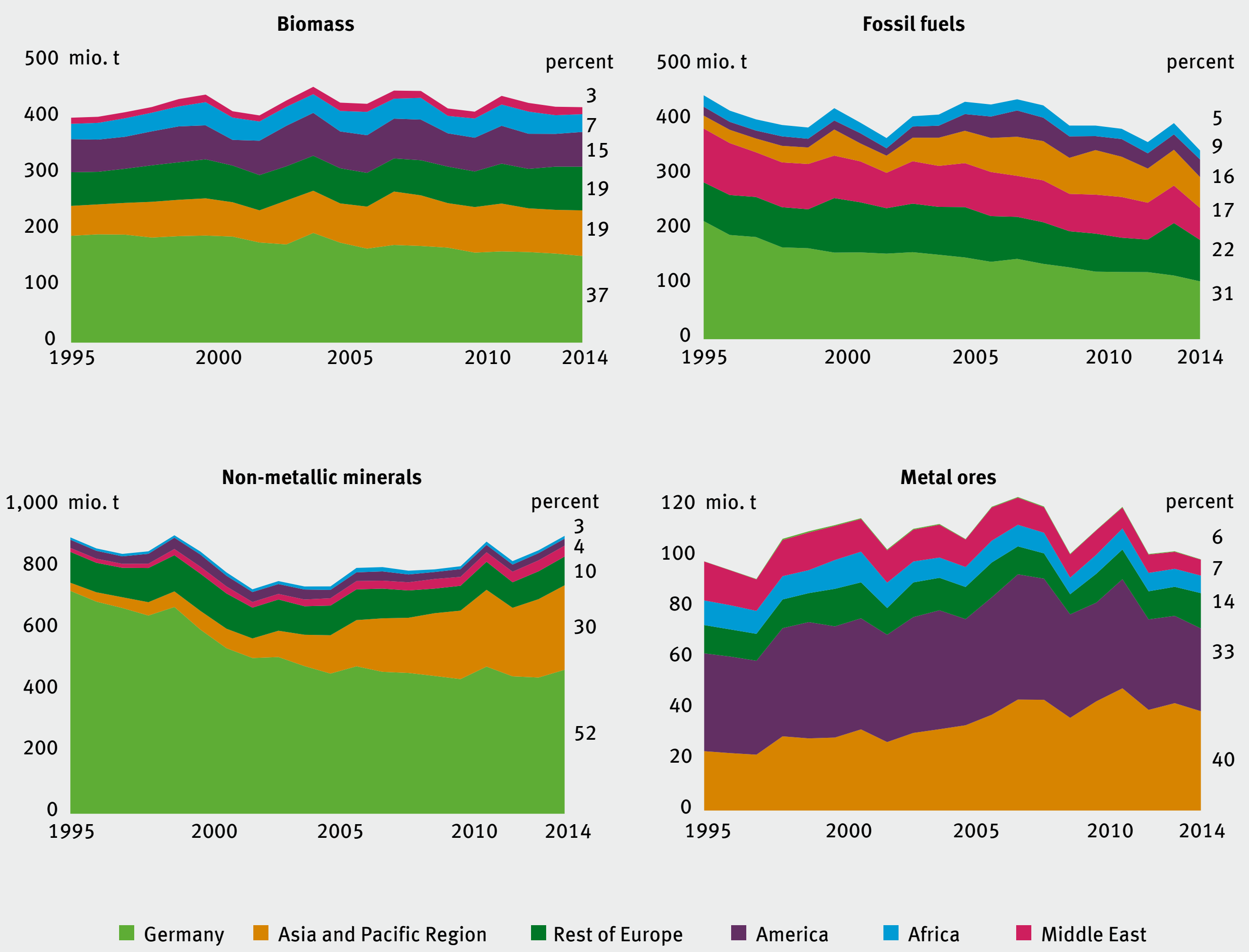


Figure 21

Source: WU, 2017 a

Germany is particularly strongly reliant on imports from abroad in the case of certain other raw materials. As already mentioned, this concerns particularly metal ores (100 %) as well as fossil fuels such as oil (99 %) and natural gas (95 %). This differentiation can also provide insight into which sectors are particularly dependent on international supply chains. Alongside the energy and metal processing sector, this is also the case for sectors such as the pharmaceutical industry or agriculture, with its demand for chemical products and fertilisers.

If one focuses on the goods and services finally consumed in Germany, the model calculations also provide a more differentiated view of the countries of origin. In comparison to 2013 (⇢ pp. 32/33, UBA Resource Report 2016), countries of origin have changed very little. In each case, roughly one-fifth of biomass came from another European country or from Asia. Europe, i.e. Russia (gas) and Norway (oil), the Middle East (oil) and Asia, where China was the most important indirect supplier of coal, were the key suppliers of raw materials where fossil fuels were concerned.

The Asia-Pacific region, and China in particular, was among the most important supply countries or regions for Germany in 2014, especially for non-metallic minerals and metal ores, e.g. in the form of machinery components or finished machinery products (↖ Fig. 21). Metal ores came almost entirely from outside Germany (Asia-Pacific 40 % and America 33 %), in which respect countries such as China and Australia in the Asia-Pacific region, together with Latin American countries in the American region played a central role as raw material suppliers.

Looking at the trend during the period 1995–2014, a significant reduction in the share of raw materials originating from Germany or elsewhere in Europe can be determined. This is most clearly visible in the case of non-metallic minerals, where Germany's share fell from 81 % to 52 %. However, also in the case of fossil fuels (minus 17 percentage points) and biomass (minus 10 percentage points), do foreign countries play an increasingly important role. All world regions are becoming more important for Germany's globalised economy. The share of raw material flows from Asia-Pacific to Germany alone increased across all four categories by a factor of eight. European countries play a more important role particularly regarding biomass and fossil energy sources than they did 20 years earlier.

International interdependencies: The example of phosphorus

Phosphorus well illustrates the way in which Germany is embedded within a system of international raw material trade. As with the majority of European countries, Germany is 100% dependent on imports of this raw material. However, global reserves of non-metallic minerals containing phosphorus are concentrated in only a few countries. More than 17 kilogrammes of phosphate were used per hectare of agricultural land in Germany in 2015. This represented a total volume of about 288,000 tonnes.

Phosphorus is important for animal and plant nutrition and a key component of fertilisers, together with nitrogen and potash. In Germany in 2014, almost 288,000 tonnes of phosphorus with a total value of 252 million Euro were supplied in the form of fertilisers (Fig. 22). In the previous year, the figure was as high as 301,000 tonnes. Phosphorus has a particularly high strategic and ecological relevance because of its limited availability and the effects of its use.

In the long-term trend, the volume of phosphorus used as fertiliser in Germany from 1999–2015 fell by roughly 32%. Thus the amount used in 1999 was 133,000 tonnes greater than the figure for 2015. Apart from some fluctuations, an ongoing decrease in phosphorus usage can be observed in this period. An exception is the year 2008, in which it almost halved. This development reflects a collapse in the domestic extraction of fertiliser minerals, in particular of potash (pp. 14/15, "Non-renewable raw materials"). The financial crisis and rising prices (Fig. 22) meant that less fertiliser was sold and instead stocks were reduced.

Phosphorus is a good example of a raw material for which prices fluctuate and are dependent on world markets. While a kilogramme of phosphate (the form of phosphorus in fertiliser) cost roughly 60 cents up to 2006, the price rose dramatically until 2008, when it reached almost 1.50 Euro per kilogramme. When a large quantity was purchased in 2007, the expenditure rose to 285 million Euro, representing the highest value for the entire period from 1999 to 2015.

While the phosphorus price fell again in 2009, it remained at around 90 cents per kilogramme, about 50% higher than the level before the financial crisis at the end of 2008. In other words, although the amount of phosphorus used fell over time, overall costs rose by 3%.

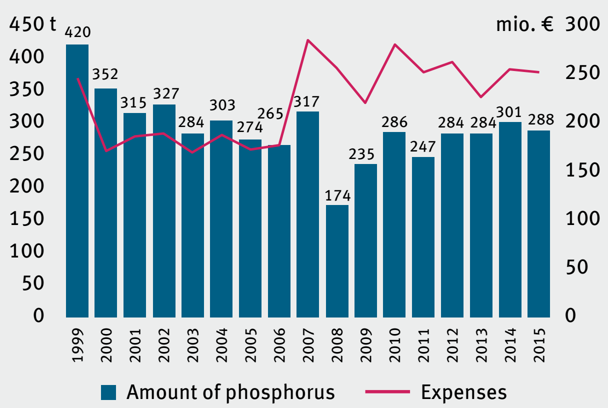
In significant amounts, phosphorus is found in the natural world only bound in non-metallic minerals, although the proportion of utilizable phosphate (P_2O_5) can vary considerably (USGS, 2016). A further source of phosphorus is found in the droppings of marine birds (guano). 90 % of the phosphorus produced is used for fertiliser (Lange, 2009).

A specific characteristic of phosphate minerals is the concentration of deposits in only a few regions of the world. Morocco and Western Sahara hold almost three-quarters of the world's reserves; China, the country with the second largest deposits, contains only 5% of global reserves (Fig. 23) (USGS, 2015a). Nonetheless, China is the world's largest producer of phosphorus and extracted 120 million tonnes in 2015. China together with Morocco and Western Sahara (29 million tonnes) and the USA (27 million tonnes), are responsible for 73 % of the worldwide extraction of phosphorus-containing minerals. Germany, in contrast, imports the phosphorus it uses largely from other producer countries, i.e. Russia and Israel (United Nations, 2017).

Through the tripling of phosphorus production since 1970 (UN IRP, 2017) and the concentration of global deposits partly in politically unstable regions, phosphorus now counts as a critical raw material (Box). Supply bottlenecks and the volatile price trends described above are a particular risk for countries like Germany, which have a highly industrialised agriculture but no domestic phosphorus deposits.

Phosphorus use can be problematic not only in economic terms but also from an ecological perspective, since fertiliser and its ingredients impact on plant growth in ways that are not only positive. Inefficient use (for example, through over-use of fertiliser) results in a large share of the applied phosphorus not being absorbed by the plants but ending up in water bodies instead, through leaching and erosion. By that means the phosphorus enters watercourses, lakes and oceans, and, alongside wastewater from cities, leads to their excessive enrichment with nutrients (eutrophication). As a consequence, algae blooms and

Development of phosphorus use and costs in Germany, 1999–2015



Years refer to the financial year, which begins on 1 July and ends on 30 June the following year (e.g. 2015 for the financial year 2015/2016).

Figures for phosphorus quantities refer to the phosphate (P_2O_5) content.

Figure 22 Source: Destatis, 2016a

World-wide phosphorus reserves, extraction and consumption, 2014

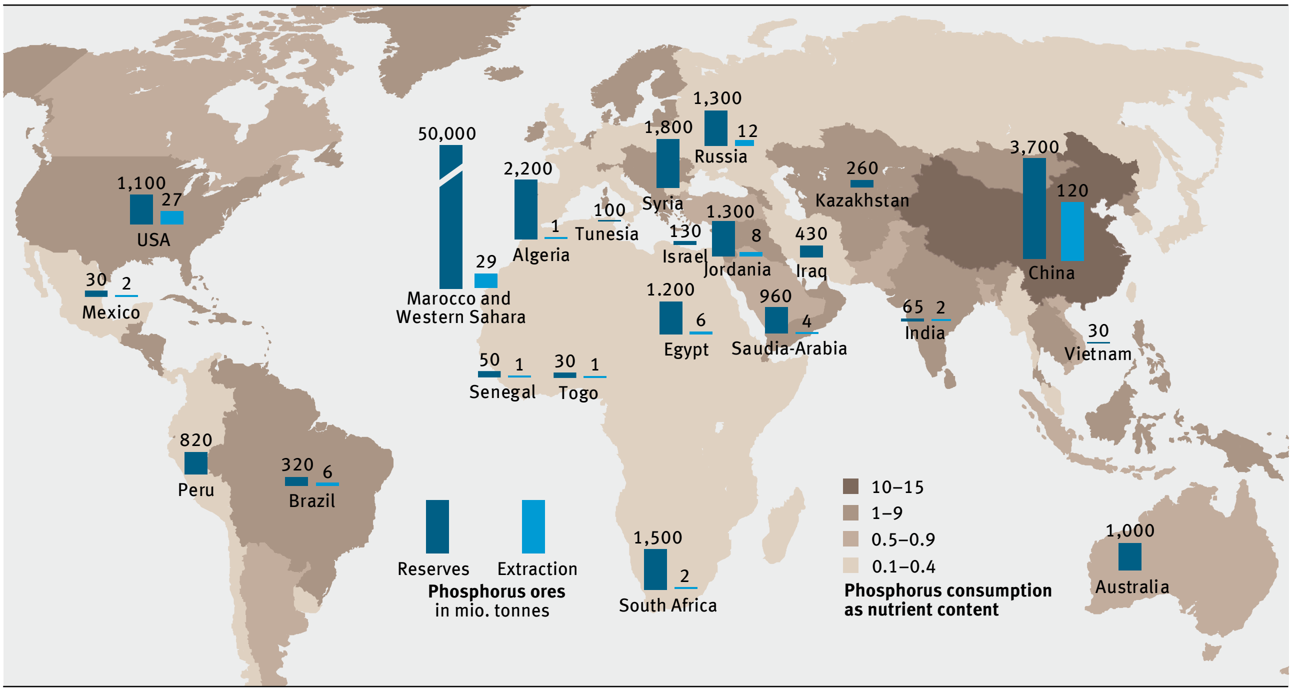


Figure 23

Sources: FAOSTAT, 2017; USGS, 2015 b und 2016

oxygen depletion occur, which can kill fish or produce blooms of toxic blue algae (Destatis, 2016 b). In global terms, the use of phosphorus has already exceeded sustainable limits for a considerable time (Steffen et al., 2015).

Agriculture can thus have impacts further downstream and even in distant regions, such as the Danube Delta or the Black Sea. In recognition of this fact, benchmark values for water quality set out in the Surface Waters Ordinance are to be achieved at all measurement stations by 2030 (Deutsche Bundesregierung, 2016 a).

Alongside the economic risk and the problem of eutrophication, the environmental impacts of phosphorus mining represent a further reason for aiming at a more efficient use of phosphorus. For example, phosphate rock often has a very high cadmium and uranium content (World Nuclear Association, 2015). Consequently, during the use in fertilizers, but also during production processes, through the development of dust and polluted groundwater contamination can occur.

Sewage sludge from wastewater treatment plants is an alternative source of phosphorus, the potential of which to provide a complete substitution for traditional sources has not yet been fully explored. For this reason, the German Federal Government passed an amendment to the Sewage Sludge Ordinance and modified the manure law in 2017. The amendment tightened the regulations on soil-based sewage sludge recovery and, for the first time, provided guidelines on recovery of phosphorus from sewage sludge and sewage sludge incineration ashes (Deutsche Bundesregierung 2017 a, b).

Criticality of raw materials

To evaluate the scarcity of raw materials, so-called criticalities can be analysed. A raw material is regarded as critical when its supply is at risk and these supply problems represent a threat to a company or a national economy. Over time, different approaches have been used and refined to evaluate the criticality of raw materials. The Society of Germany Engineers (Verein Deutscher Ingenieure, or VDI) has developed a method that encompasses three areas of criteria: (1) geological, technical and structural criteria, (2) geopolitical and regulatory criteria and (3) economic criteria (VDI, 2016). Because they do not take account of ecological components, the existing approaches are, however, not com, prehensive enough. Only when ecological criticality is considered it is possible to design measures to ensure a responsible approach to mining and production methods.

In this context, the ÖkoRess project by the German Environment Agency has explored if and how environmental aspects can be integrated within criticality concepts. A raw material is defined as environmentally critical when the mining processes used to obtain it show a high potential for causing environmental damage, while being simultaneously of great importance for a company or national economy. For this analysis a system of indicators was developed to identify how likely and to what extent negative impacts from mining and production processes will occur. This is a qualitative form of analysis. For categorisation purposes, two quantitative indicators are included, which represent the scale of worldwide production both in energy and in volume units (UBA, 2017 b).

The role of the economy

2,653
mio. tonnes
-5.0%

2,665
mio. tonnes
+0.5%

2,643
mio. tonnes
-0.8%

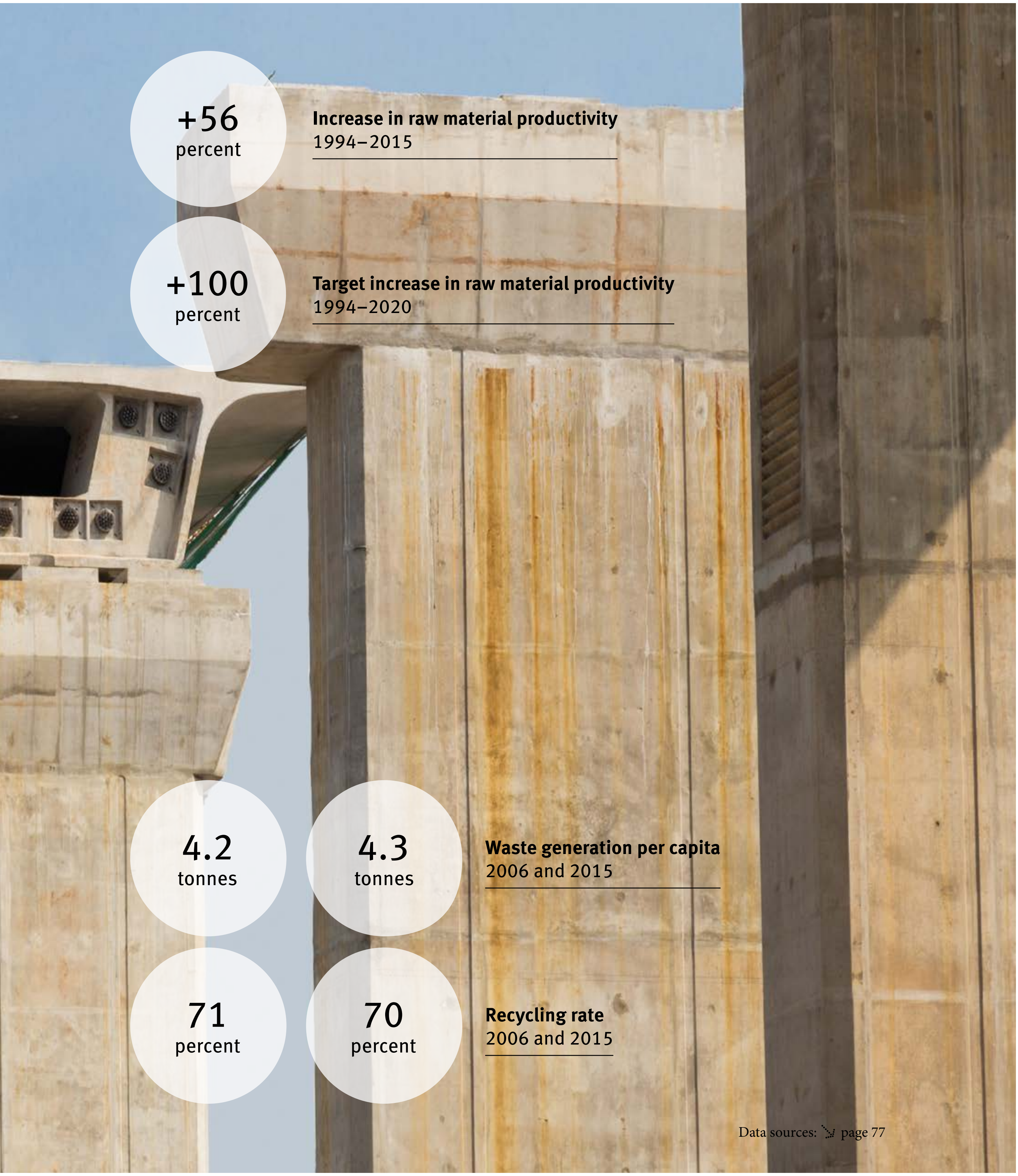
Raw material input (RMI)
2012, 2013, 2014, change from the previous year

1.9
percent

Average annual increase in total material productivity
2010–2014

1.5
percent

Target annual increase in total material productivity
2010–2030



+56 percent
Increase in raw material productivity
1994–2015

+100 percent
Target increase in raw material productivity
1994–2020

4.2 tonnes | **4.3 tonnes**
Waste generation per capita
2006 and 2015

71 percent | **70 percent**
Recycling rate
2006 and 2015

Data sources: page 77

Raw material input in the economy

For the production of goods and services, the economy requires large quantities of raw materials. In 2014, the so-called Raw Material Input (RMI) amounted to 2.6 billion tonnes, which were used as inputs along the value chains. Supply structures of intermediate products for individual economic sectors vary greatly and are becoming ever more complex as a result of increasing globalisation.

Raw Material Input (RMI) refers to all raw materials that are used in an economy, both directly in production and indirectly via the inputs of intermediate products, in order to produce goods. The RMI comprises the total volume of primary raw materials extracted domestically plus the imported raw materials, as well as semi-finished and finished products converted into raw material equivalents. (↖ pp. 28/29, “The geographical origin of raw materials”). It thus accounts for the quantity of raw materials from which the economy creates its value added.

In 2014, Germany’s RMI amounted to 2.6 billion tonnes (raw material equivalents), of which 58 % stemmed from foreign sources (↖ pp. 28/29, “The geographical origin of raw materials”). The decrease of 1 % from the previous year ran counter to the trend of preceding years – since 2010, the RMI had risen by 1 % (↘ Fig. 24). Combining the assessments for the periods 2000 – 2010 and 2010 – 2014, raw material inputs rose by as much as 4 %.

Examining the distribution of RMI across individual material groups, it is evident that metal ores, fossil fuels and non-metallic minerals have roughly equal shares (26 – 28 %) in the total quantity. Only the share of biomass, at 18 % is somewhat lower.

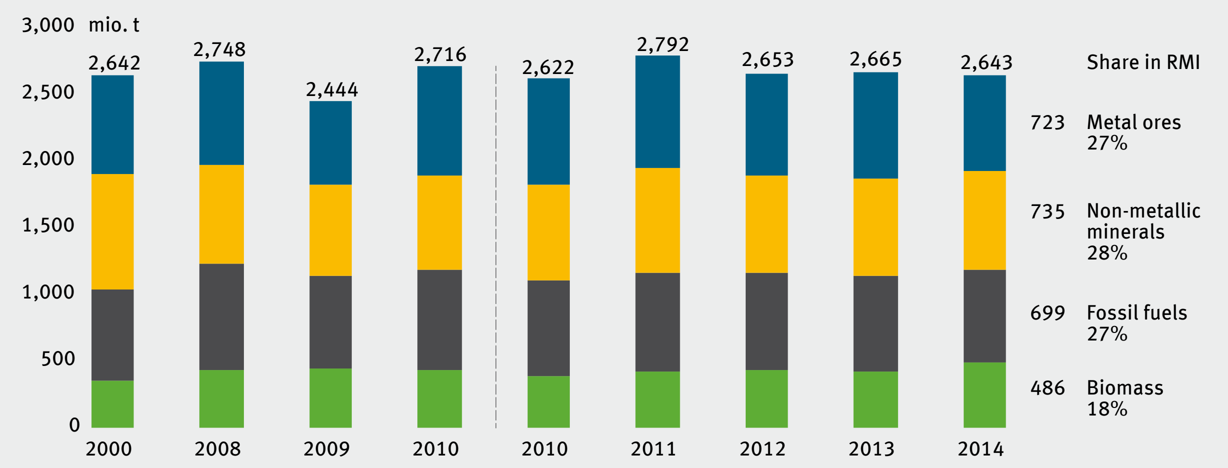
The German economy compensates for the limited domestic availability of individual raw materials by means of trade. Domestic extraction of metal ores, for example, is marginal (↖ pp. 14/15, “Non-renewable raw materials”), yet via imports, direct and indirect inputs of 723 million tonnes are used to produce goods and services. Metal ores thus represent the largest import flow in RMEs.

Calculations for the raw material inputs for individual sectors or sector groups can only be undertaken for the production of goods and services for final demand, since otherwise double counting would occur. The quantity of iron ore, for example, that is used in the production of sheet steel and is attributed to the manufacturing sector, would also be attributed to the automobile sector, which makes final use of the sheet steel.

If we consider only the final demand goods produced in Germany, which are consumed in or outside the country, the raw material input for 2014 amounted to 1,475 million tonnes, which signifies a slight increase of 1 % in comparison to 2013. Looking at the long-term trend, a decrease of 7 % can be observed in the period 1995 – 2014 (WU, 2017 a). This means that there was only a negligible decrease in raw material input for the German economy for the production of final demand goods.

The RMI of goods for final demand varies greatly between primary, secondary and tertiary sectors. The primary sector consists of those economic actors that extract raw materials

Raw material input (RMI) in Germany by material group, 2000 – 2014



For the periods 2000–2010 and 2010–2014, different revisions of the national accounts have been used; i.e. they are based on different calculation bases. While the absolute values are not directly comparable, the development of trends can be combined.

Figure 24 Source: Destatis, 2018

* The great difference between the figure of 1.9 billion tonnes reported in the UBA Resource Report 2016 for the year 2011 and the figure of about 1.5 billion tonnes for 2014 does not indicate an actual decrease but rather an adaption of the data basis, EXIOBASE 3.3. Using the new calculations, the value for 2011 is just over 1.5 billion tonnes.

Raw material input (RMI) of goods for final demand produced in Germany, 2014

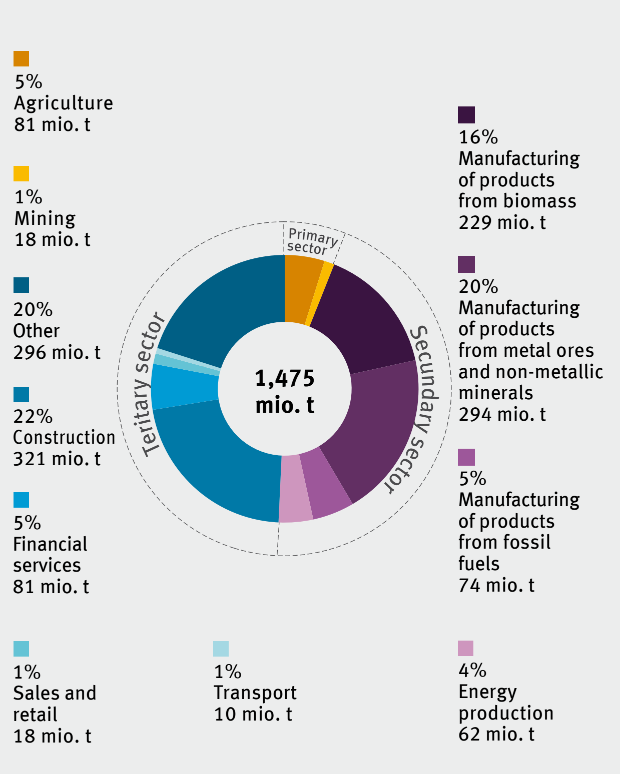


Figure 25 Source: WU, 2017 a

Comparison of supply chain structures of selected aggregated sectors, 2014

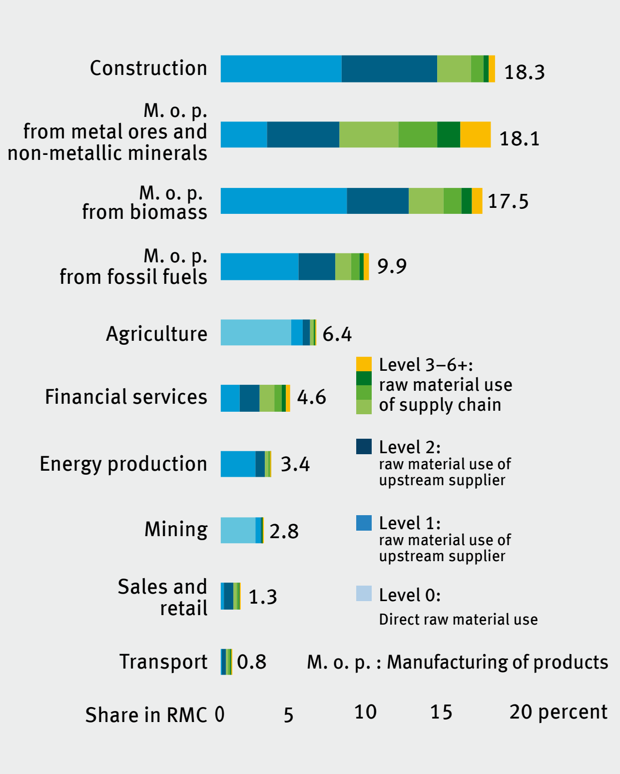


Figure 26 Source: WU, 2017 a

directly from the environment. In the secondary sector, the obtained biomass, metal ores, non-metallic minerals and fossil fuels are processed into semi-finished and finished products. The tertiary sector is primarily comprised of services. It accounts for the largest share in RMI of goods for final demand, at 49 %. The secondary sector is responsible for 45 %, while the primary sector has a relatively small share in RMI, at 6 % (↖ Fig. 25).

The construction industry had the largest share of all sectors of the German economy, with more than 320 million tonnes and 22 % of the total quantity in 2014. This was followed by the manufacture of products from metal ores and non-metallic minerals (e.g. the automobile industry) or from biomass (e.g. food processing), at about 300 million (20 %) and 230 million tonnes (15 %) respectively. These three sectors together were responsible for 57 % of total raw material input in 2014.

All sectors require more than only direct raw material inputs – for example, minerals in the construction industry or agricultural products in food processing (⇢ pp. 36/37, UBA Resource Report 2016). By means of ever more intertwined supply chains, the indirect input of raw materials is also gaining in importance (↘ Fig. 26). For example, service sectors also rely on indirect inputs of fossil fuels, e.g. through the use of ICT, for the production of which energy is required. In total, as already mentioned, 58 % of total raw material input comes from outside Germany.

Taking account of the complexity of supply chains for the individual sectors facilitates better understanding of the changes of indirect raw material input. This approach analyses the number of supply steps (layers) before the actual production process at which different quantities of raw materials are directly extracted.

Unsurprisingly, primary sectors such as agriculture and mining extract most of the raw materials they use themselves (Level 0 in Fig. 26). Yet here too, raw materials are input at intermediate supply steps (mainly at level 1) – for example, construction components or fuel for mining machinery. Manufacturing sectors, such as product manufacturing or construction, have relatively short supply chains, yet they extract no raw materials themselves. In these sectors, most extraction takes place one processing step (Level 1) or two processing steps (Level 2) before production.

In contrast, where service sectors are concerned, the indirect supply chains for raw materials are extremely complex. This is evidenced by the fact that a significant share in raw material extraction occurs at Level 3 or even higher, i.e. at least 3 processing steps before the performance of t he respective services. Raw materials are thus extracted at numerous intermediate levels to enable a particular service to be undertaken.

The different structures of the supply chains lead to different strategies for reducing the resource input along the value chains. In sectors with short supply chains, the resource input can be reduced primarily through efficiency measures in the sectors themselves and their direct suppliers. In sectors with more complex supply chains, such as services, strategies must address a whole range of delivery chains and actors involved.

Development of raw material productivity

Increasing raw material productivity combined with decoupling economic growth from raw material use and its negative environmental impacts is a central aim of a sustainable use of natural resources. Raw material productivity, i.e. the relationship between value added and direct material input, increased by 56 % in Germany during the period 1994–2015. The indicator of total raw material productivity, which also takes account of the indirect material flows of imports to Germany, rose in recent years by an average of 1.9 % per year.

In the economy, productivity is an important measure for capturing the relationship between produced goods or services (or of the value added thereby obtained) and the production factors required to create these. Raw material productivity thus indicates how much added value in Euro per unit of raw material can be achieved. An increase in raw material productivity, where the economy grows more rapidly than raw material use, is defined as relative decoupling. However, it is a key aim for a sustainable use of raw materials to achieve continuing economic growth but at the same time a reduction in raw material use – referred to as absolute decoupling.

In Germany, two different indicators are used to measure decoupling. The indicator "raw material productivity" indicates how efficient inputs of abiotic primary materials are used for the creation of Germany's GDP. In relation to the raw material production factor, raw material productivity is thus analogous to labour and capital productivity. To determine this, GDP is related to abiotic, i.e. non-renewable, materials input in Germany. Abiotic materials include those from domestic raw material extraction and those from direct imports (abiotic direct material input, DMI_{abiot}). In alignment with the German Sustainability Strategy, the second German Resource Efficiency Programme (ProgRess II) provides for raw material productivity to double by 2020 in comparison with 1994 (Deutsche Bundesregierung, 2016 a, b). Raw material productivity rose in the period 1994–2015 by 56 % (Fig. 27, l.). To achieve the envisaged goal, therefore, almost the same increase in productivity will have to be achieved in the remaining five years as has already occurred in the previous 21 years (Destatis 2017b).

DMI_{abiot} includes direct but not indirect material flows of imports (pp. 26/27, "Indirect imports and exports"). In the framework of ProgRess II and the revised German Sustainability Strategy 2016, the indicator "raw material productivity" was therefore expanded to "total raw material productivity". This indicator relates the Raw Material Input (RMI; pp. 26/27, "The geographical origin of raw materials") to the overall value creation, which is obtained with these raw materials, i.e. with the total of GDP plus the value of imports. In ProgRess II, the Federal Government set out the goal of maintaining the growth rate seen during

Development of raw material productivity, 1994–2015, (left) and total raw material productivity (right) in Germany, 2000–2014

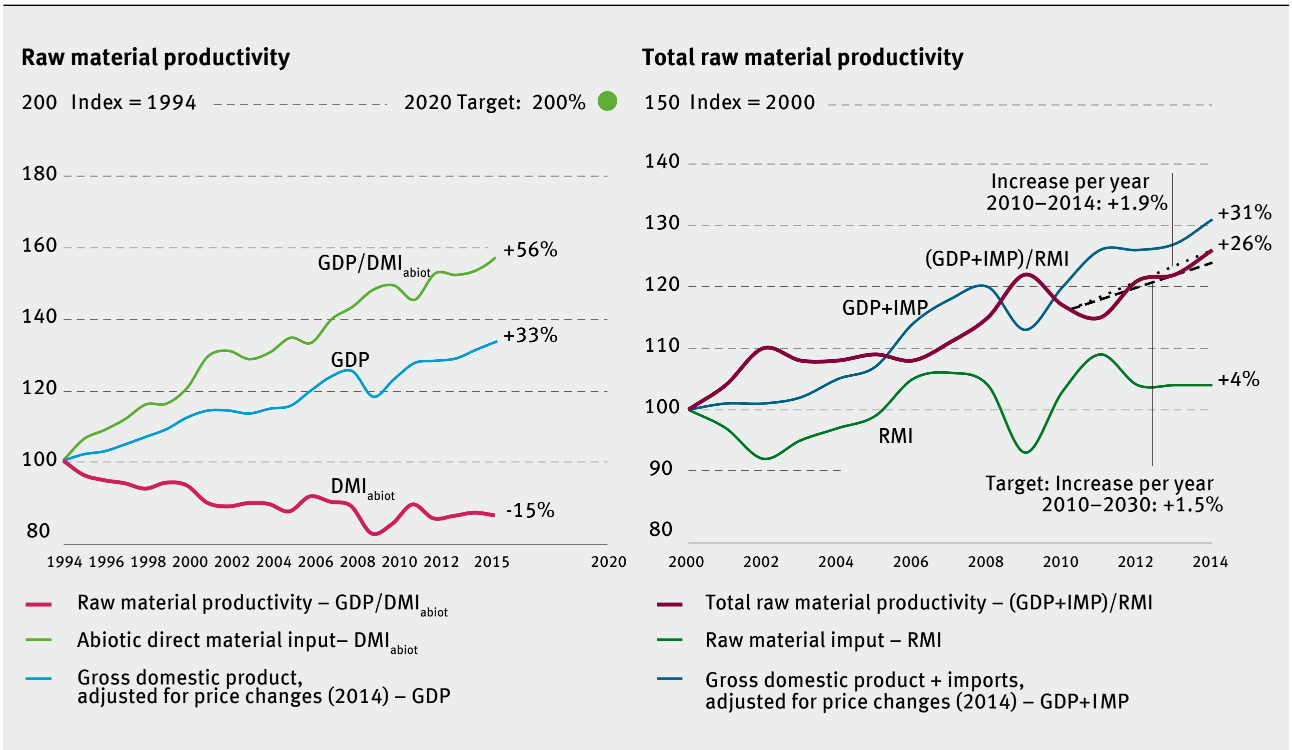


Figure 27

Sources: Destatis, 2017 b, 2018

International comparison of decoupling trends, 1995–2014

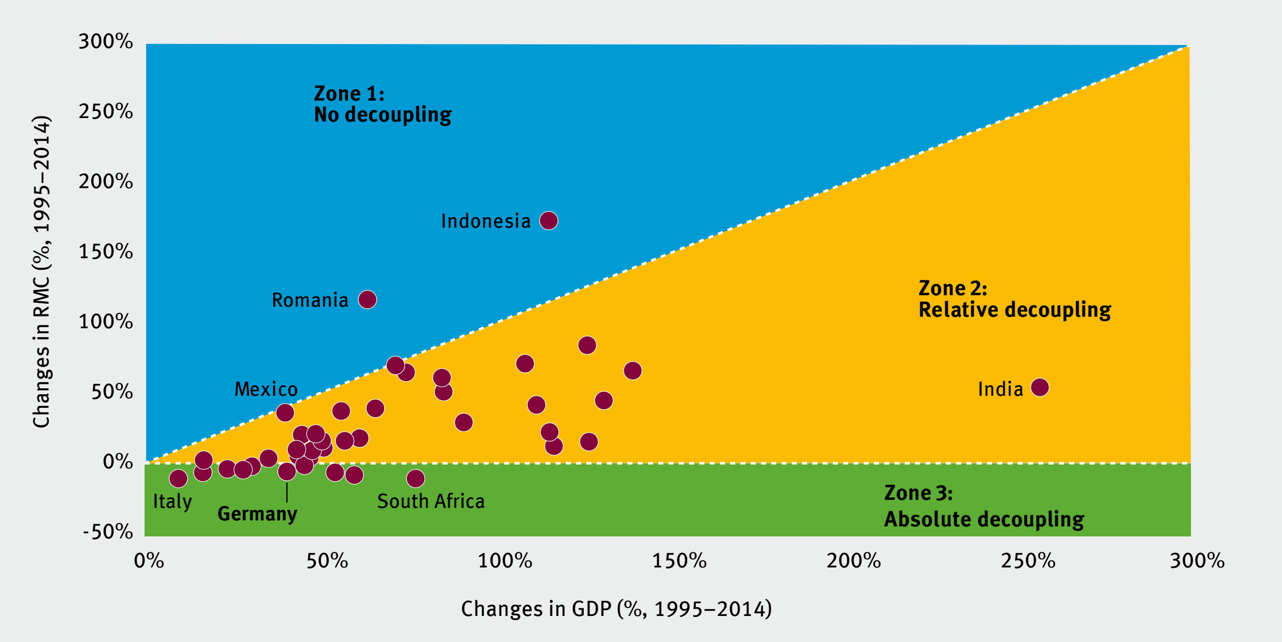


Figure 28 Source: WU, 2017 a

the period 2000–2010 of around 1.5 % through until 2030. This represents an increase of 30 % in total raw material productivity compared to 2010. The average rate of growth in the years between 2010 and 2014 thus far amounted to 1.9 % (Fig. 27, r.). In comparison to 2010, total raw material productivity in Germany rose by 8 % in total by 2014 (Destatis 2018). To maintain this trend and achieve the goal defined, ProgRess II sets out a wide range of measures.

Looking at recent years since 2011, the reference year for the UBA Resource Report 2016, it is evident that raw material productivity initially rose sharply, because of the significant reduction in DMI_{abiot}, but then remained relatively unchanged (pp. 38/39, UBA Resource Report 2016). A decrease in RMI followed by a constant level is also observable in the case of total raw material productivity. However, an increase in the value of imports has led to an improvement in total raw material productivity. This means that the generated economic value of goods has risen in the last two years, despite an unchanged RMI.

Internationally, mainly as a result of the better data availability, material productivity is calculated by relating GDP to raw material consumption (RMC). The latter comprises all raw materials that were required directly or indirectly to produce the goods and services consumed within a country. While conceptually the monetary and physical values are not directly comparable, data availability is better thus allowing the development of both GDP and raw material consumption in different countries to be monitored. It is hence possible to compare the degree to which relative or absolute decoupling has been achieved (Fig. 28).

A comparison between 49 countries and regions shows that in particular some European countries achieved an absolute decoupling during the period observed (1995 to 2014) – i.e. economic growth with the simultaneous reduction of raw material consumption. These countries included Germany, Italy, Austria and Spain. Apart from these European countries, the only other country to achieve absolute decoupling was South Africa. Together with Italy, South Africa showed the strongest decrease (minus 10 %) in raw material consumption over the period 1995–2014.

The majority of industrialised and emerging countries included in the analysis only achieved a relative decoupling. For instance, India managed to more than triple its GDP (+256 %), while its raw material consumption rose by 55 %. In Mexico in contrast, GDP and material consumption rose by almost the same amount i.e by 70 %. Only a few countries showed no decoupling, e.g. Romania and Indonesia.

However, an increase in productivity in the use of raw materials does not automatically lead to a decrease in raw material consumption. On one hand, this depends upon the indicators used (see above). On the other hand, increases in efficiency during production can lead to greater demand, because production costs are reduced. Avoiding this phenomenon, known as the rebound effect, requires political instruments, such as the introduction of taxation related to raw material input (Santarius 2014).

Circular economy in Germany

The term "circular economy" refers to the conservation of natural resources through the creation of closed material cycles in production and consumption. Waste management policy is an important part of the circular economy, since it ensures that waste can be recovered again, i.e. recycled. 70 % of the total quantity of waste generated in Germany was recycled in 2015. The circular economy should, however, be interpreted in a more comprehensive way, beginning at the stage of product design and thus incorporating the entire life cycle of products.

Recycled and recovered raw materials play a crucially important role in achieving a reduction in the use of primary raw materials. The so-called circular economy is thus also an important pillar of the second German Resource Efficiency Programme (Deutsche Bundesregierung, 2016 b). In alignment with the Circular Economy Act (KrWG; Deutsche Bundesregierung, 2012), the focus here lies with the management of generated waste and the target hierarchy related to this. First on the five-tier list of the waste management hierarchy is (1) waste prevention, followed by (2) waste recovery/reuse. Where these two options are not available, waste should be (3) recycled or (4) recovered in other ways, particularly for energetic use and backfilling. Lastly, (5) waste should be disposed of in landfill or permanent storage.

No other country in Europe produces as much waste as Germany. In 2015, total waste generated amounted to 351 million tonnes. This represents 4.3 tonnes per capita and year. The total quantity of waste has decreased only by 9 % since 1996. In recent years, from 2012 to 2015, waste generation actually rose by 5 %. In 2015, 59 % (209 million tonnes) of all waste generated came from construction and demolition, 15 % (52 million tonnes) was municipal waste and 9 % (31 million tonnes) was waste generated from mining activities (↘ Fig. 29).

Out of the total waste generated, approximately 78 % was subject to material or thermal recovery, i.e. recycled or incinerated to provide energy (↘ Fig. 30). Hence, to 1.1 billion tonnes of primary raw materials from domestic extraction (↖ pp. 14/15, "Domestic extraction: Non-renewable raw materials"), 274 million tonnes of secondary raw materials were added in 2015. This represents approximately 26 % of the raw materials from domestic extraction and 10 % of German RMI.

Types of waste generation in Germany, 2015

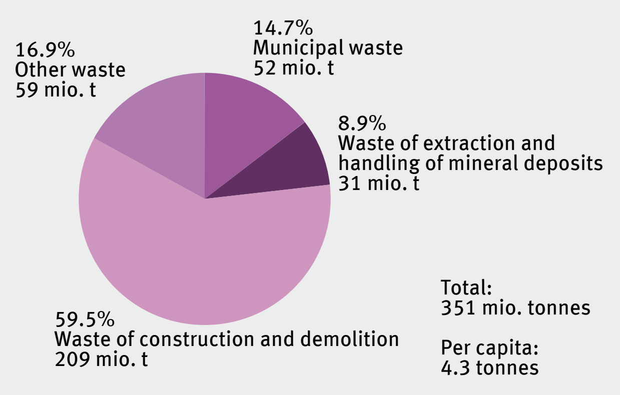


Figure 29 Source: Destatis 2017 e

To reduce pressure on the environment, both the quantity of waste disposed and used for landfill and the quantity of waste used for energy generation need to be reduced. Material recovery, i.e. recycling, has long been a key priority in German waste management. As described in the UBA Resource Report 2016, where recycling is concerned, it is not only important to reduce the use of primary raw materials but also to cut emissions arising during their production (⇢ pp. 42/43, UBA Resource Report 2016). For example, the recycling rate for lead is 62 % with almost no associated emissions occurring. Recycling efforts in Germany appear

Preventing food waste as a part of the circular economy

Both raw materials and large amounts of water and land are required for the production of foodstuffs, which leads to emissions and waste. Hence, the more waste is generated in the food industry, the more other resources are also squandered. Food waste is generated at all stages through production and consumption – during agricultural production, in sales and distribution, and during the "consumption phase". In Germany, from the 456 kilogrammes of food consumed by households, per capita and year around 81 kilogrammes (18 %) are disposed of as waste. In so-called "away-from-home consumption", at least one-third of the prepared food is disposed of prematurely. Per person, 23.6 kg of prepared food is thus wasted each year.

Purchasing only what is needed in terms of food and avoiding the generation of food waste can thus play an important role in contributing to the conservation of resources and the circular economy. Voluntary agreements by the food retailing sector and the catering industry to reduce food waste are also key to reducing the waste of resources. The Federal Waste Prevention Programme (Deutsche Bundesregierung, 2013) provides for a relaxation of the legal and trading standards applied to the appearance and shape of food items. Guidelines that render further distribution or donation of edible foodstuffs unnecessarily difficult should also be challenged (UBA, 2015 b).

Trend of shares of thermal and material waste recovery and disposal in Germany, 2006–2015, by waste type, 2015

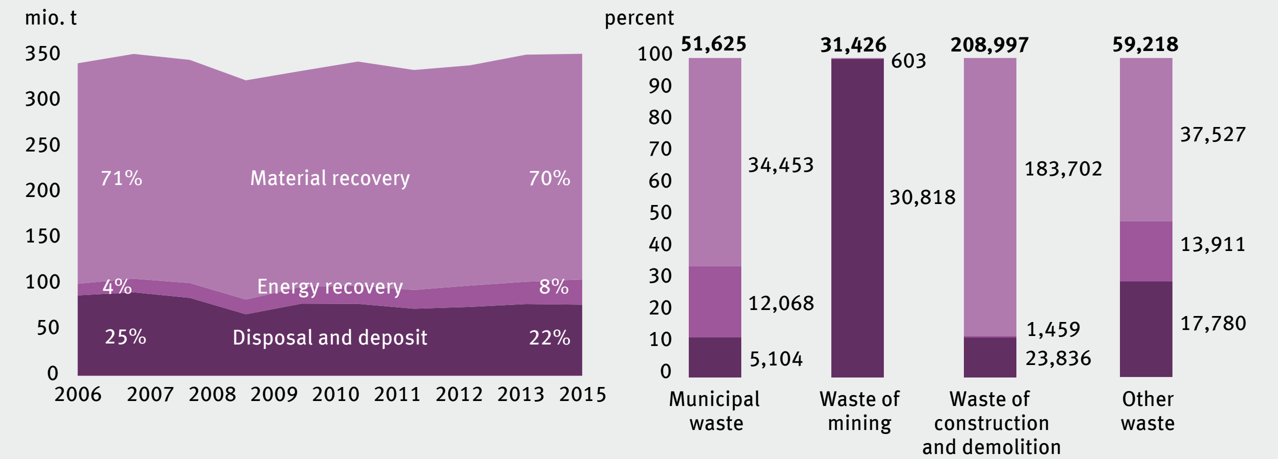


Figure 30 Source: Destatis 2017 e

to be stagnating, however. In 2006, 71 % of total waste generated was recycled, while thermal treatment of waste accounted for 4 % of the total. By 2015, the recycling rate had fallen to 70 % and the rate for thermal treatment was 8%. This development indicates the lack of progress made during 2006–2015 in creating the circular economy through a continuing increase in the recycling rate (↘ Fig. 30).

Non-recycled waste was either placed in landfill or incinerated. The recovery rates differed, however, according to the type of waste product. In the case of municipal waste, 90 % was recovered (67 % recycled, 23 % recovered thermally). 89 % of construction waste was also recovered, of which almost 100 % was recycled (Destatis, 2017 e). The construction sector as one of the most resource-intensive economic sectors, (↖ pp. 34/35, “Raw material input in the economy”) is a key sector in terms of environmental policy because of the large volume of construction waste it generates. Mineral construction waste, such as building rubble, road construction waste or construction site waste, comprised 202 million tonnes in 2015. About 86 % of excavated material and 95 % of soil waste underwent recovery processes such as landfill construction or placement in excavation voids (Kreislaufwirtschaft Bau, 2017).

Examination of the trend of waste management according to waste type from 2006 shows that the recycling rate in the case of municipal waste increased by 5 percentage points while the share of incinerated waste rose by 15 percentage points. Material recovery of mining waste only began in 2009, although the share was always comparatively marginal, with no history of thermal recovery. Where construction and demolition waste products are concerned, there was little observable change in the share of processing types during the period. The share of disposed waste remained more or less constant at 10–12 % while that of material recovery remained within the range 88–90 %.

The second German Resource Efficiency Programme and the European Commission’s Action Plan (⇢ Box) nonetheless expand the definition of the circular economy from simple waste management to include waste avoidance and product design as well as repairability. Extending the lifespan of goods is a key priority of product design, together with greater potential for repair and recycling.

The circular economy at European level

In recent years, a more comprehensive understanding of the circular economy has become established. This starts at the very beginning of the lifecycle of a product and thus long before waste management comes into play. This approach takes account of procurement and product design as well as recycling and recovery. Waste management is thus only a part of the circular economy. This approach is also reflected in the second German Resource Efficiency Programme (Deutsche Bundesregierung, 2016 b), which views the circular economy as a crucial support for the conservation of resources. The EU Circular Economy Action Plan published at the end of 2015 (EC, 2016) focusses on the broad application of this comprehensive approach and places emphasis on product design, which is now to be given greater priority in the framework of the Ecodesign Directive. The aim is to ensure not only the reparability but also the long lifespan of goods through appropriate and innovative design. In addition, however, target values are defined in the area of waste production, such as in the area of household waste where a recycling rate of 65 % should be achieved across Europe by 2030. There was emphatic criticism of the Action Plan when a revision of the Plan saw specific efficiency targets removed. On the positive side, the revision also achieved broader institutional support within the EU Commission for the Action Plan itself.

Raw materials for consumption

Raw material consumption (RMC) of final demand, absolute
2012, 2013, 2014, change from the previous year

2012	2013	2014
1,258 mio. tonnes	1,274 mio. tonnes	1,303 mio. tonnes
-8.6 %	+1.3 %	+2.3 %

Raw material consumption (RMC) of final demand, per capita
2012, 2013, 2014, change from the previous year

2012	2013	2014
15.6 tonnes	15.8 tonnes	16.1 tonnes
-8.8 %	+1.0 %	+1.9 %

49 percent

Share of private consumption in raw material consumption (RMC) of final demand
2014

13 percent

Share of public consumption in raw material consumption (RMC) of final demand
2014

1,343 mio. tonnes +13.9 %

1,284 mio. tonnes 4.4 %

Domestic material consumption (DMC)
2014, 2015, change from the previous year

101 mio. tonnes

Raw material consumption (RMC) in the health sector
2014

269 mio. tonnes

Raw material consumption (RMC) for food
2014

558 kilogramme

Raw material consumption (RMC) for food per household and month
2014

455 Euro

Expenditures for food per household and month
2014

Data sources: page 77

Composition and trends of final demand

In 2014, raw material consumption of final demand in Germany amounted to 1.3 billion tonnes or 16.1 tonnes per capita. Per-capita consumption thus fell by about 17 % from 2000, and by about 5 % from 2011. Most raw material consumption in 2014 consisted of non-metallic minerals (45 %), fossil fuels (29 %) and biomass (21 %). The most important product groups were those based on biomass, such as foodstuffs, and products used in the construction industry.

Different indicators can be used to evaluate a country's requirements for raw materials. Whereas domestic material consumption (DMC) focuses on the quantity of domestic extraction and direct trade flows, raw material consumption (RMC) also considers indirect raw material flows (pp. 26/27, "Direct and indirect trade"). Finally, total material consumption (TMC) also includes the quantity of unused extraction such as overburden. As described in the metholodogy section of this resource report, raw material consumption is calculated using economy-environment models (pp. 10/11, "Methodological background").

In 2014, Germany's DMC amounted to approximately 1,343 million tonnes of raw materials. It was 22 % higher than the 1,103 million tonnes of domestic extraction (pp. 14/15, "Non-renewable raw materials"). This represented a per-capita figure of 16.5 tonnes. The RMC of German final demand in the same year was only 1,303 million tonnes (in raw material equivalents), or 16.1 tonnes per capita (Fig. 31). In comparison, the most recent figures for TMC for 2010 showed that in Germany this was almost three times as high as RMC (pp. 48/49, UBA Resource Report 2016).

The difference between DMC and RMC is due to the fact that, although the direct trade flows are smaller than those in raw material equivalents, the import surplus (i.e. the difference between imports and exports) is nonetheless greater in the case of direct flows (pp. 26/27, "Indirect imports and exports"). The reason for this is that the German economy, which has a highly developed manufacturing and services sector and a high level of consumption, imports large quantities of goods that are linked to significant indirect raw material flows. However, since many goods are also re-exported after further processing and increasing in value, the indirect flows linked to these exports are allocated to the countries that import such products from Germany.

A similar development is evident for both indicators, when compared with preceding years. The DMC fell from 1.35 billion tonnes in 2011 to 1.29 billion tonnes in 2012, before almost reaching the 2011 figure again in 2014 (-0,4 %). The RMC also fell initially from 1.38 billion tonnes in 2011 to around 1.26 billion tonnes in 2012, measuring 5 % below the baseline value at 1.3 billion tonnes in 2014. It is noteworthy that the per-capita values fell more sharply than the absolute values in the case of both indicators. This situation can be attributed to population growth, since a growing population combined with constant raw material consumption leads to a decrease in per-capita consumption

Domestic material consumption (DMC) and raw material consumption (RMC) in Germany, in absolute values by material group, 2014; and per capita, 2011–2014*

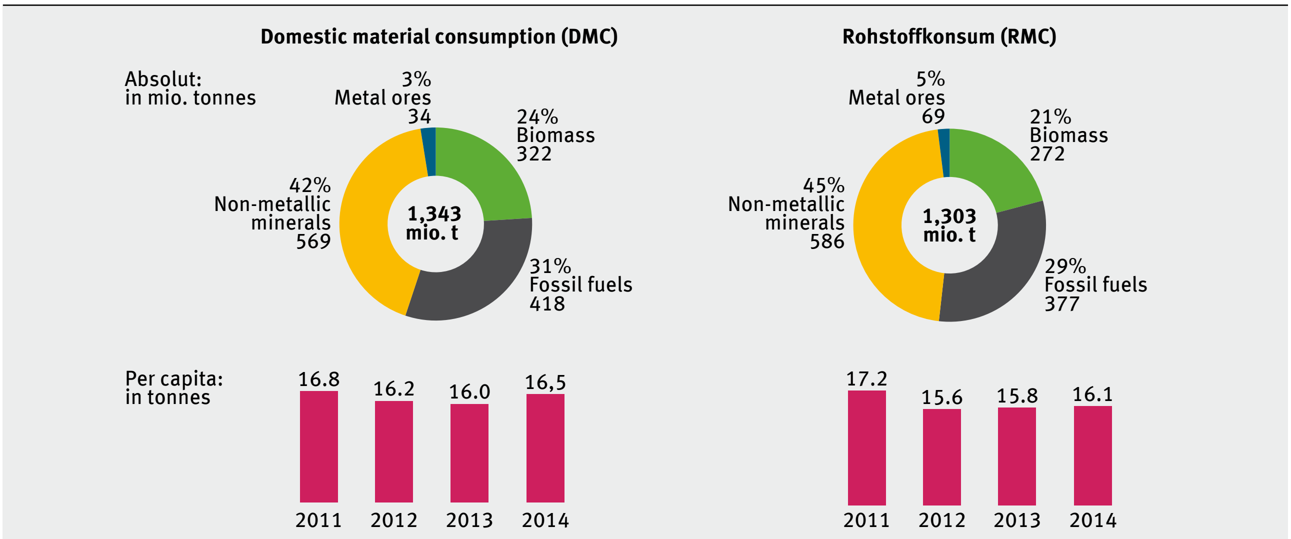


Figure 31 Sources: Destatis, 2017 a, 2018

* DMC and RMC are indicators employed in material flow analysis (MFA). The numbers presented in this report are based on the most recent calculations by the German Statistical Office (Destatis). Modified estimation methods and data corrections both by Destatis impede a direct comparability of the values for DMC and RMC indicators with the ones in the Resource Report 2016 (pp. 48/49, UBA Resource Report 2016). Further methodological details are found in the "Methodological background" section (pp. 10/11), information regarding the indicators DMC and RMC is provided in the Glossary (pp. 62/63).

Development of raw material consumption (RMC) in Germany by raw material group, 2000–2014

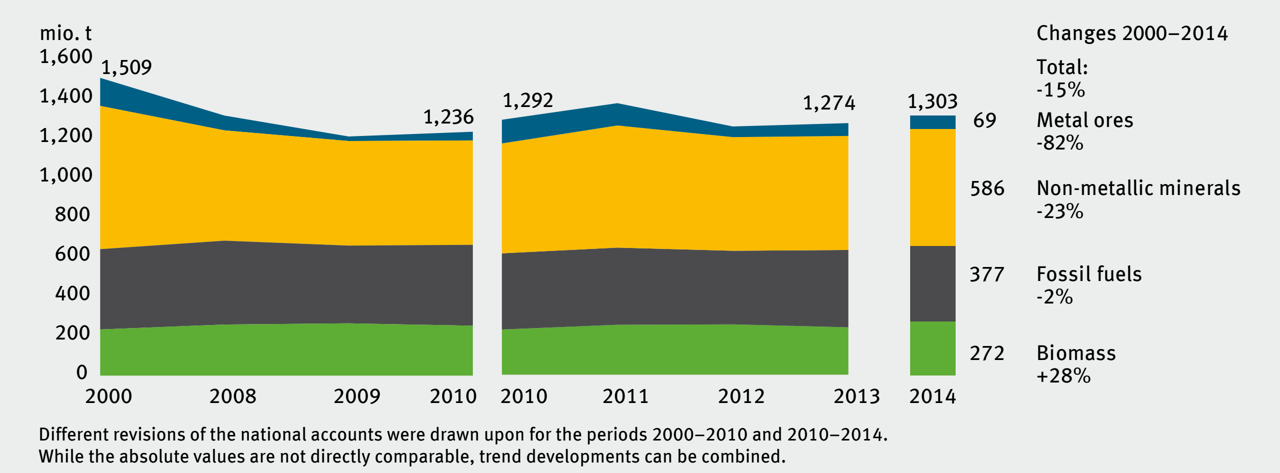


Figure 32 Source: Destatis, 2018

(Destatis, 2017 b). Per-capita RMC, at 16.1 tonnes, lay some 10 % above the European average of 14.7 tonnes (EUROSTAT, 2018). The largest share in total consumption for both DMC and RMC comprised non-metallic minerals, at 42 % and 45 % respectively, followed by fossil fuels (31 % and 29 %) and biomass (24 % and 21 %).

In the long term, a decrease in RMC of 17 % can be observed for the period 2000–2014 (↘ Fig. 32). Nonetheless, the development of individual raw material categories varied. The consumption of metal ores fell most strongly, reducing by 82 % to 69 million tonnes. The consumption of non-metallic minerals and fossil fuels decreased by 23 % (to 586 million tonnes) and 2 % (to 377 million tonnes) respectively. Only biomass consumption increased by 28 % and reached approximately 272 million tonnes in 2014.

Although raw material consumption fell more sharply compared with domestic extraction, which decreased in the period 2000–2014 by about 10 %, it still remained in absolute values at 18 % above extraction in 2014. Similarly to the trend described in the economy section, this confirms that also consumption in Germany is based to a significant degree on raw materials coming from abroad (↖ pp. 34/35, “Raw material inputs in the economy”). This is all the more the case because a significant share of domestic extraction does not flow into domestic final demand but is exported directly or via processed goods.

The consumption of raw materials occurs through the demand for products and services provided by different economic sectors (↖ Fig. 33). With regard to German final demand, three economic sectors played the most important role in quantitative terms in 2014, similarly to the previous three years: the construction industry, due to its raw material inputs for buildings and infrastructure (18.3 %), production based on biomass (18.1 %) and production based on metal ores and non-metallic minerals (17.5 %).

Creating these products involved not only the main raw materials but also other raw material groups. For example, fossil fuels are used in the form of fuel in various production phases. Similarly, biomass, for example in the form of food, is required in the metalworking industries.

Further to this, other sectors of the economy with low direct raw material inputs also contributed to total raw material consumption. Thus, for example, financial services indirectly required a significant quantity of non-metallic minerals in the form of utilized infrastructure. Distribution and retail also consumed biomass, which they passed on to final demand.

Shares of economic sectors in the raw material consumption of final demand in Germany, by raw material group, 2014

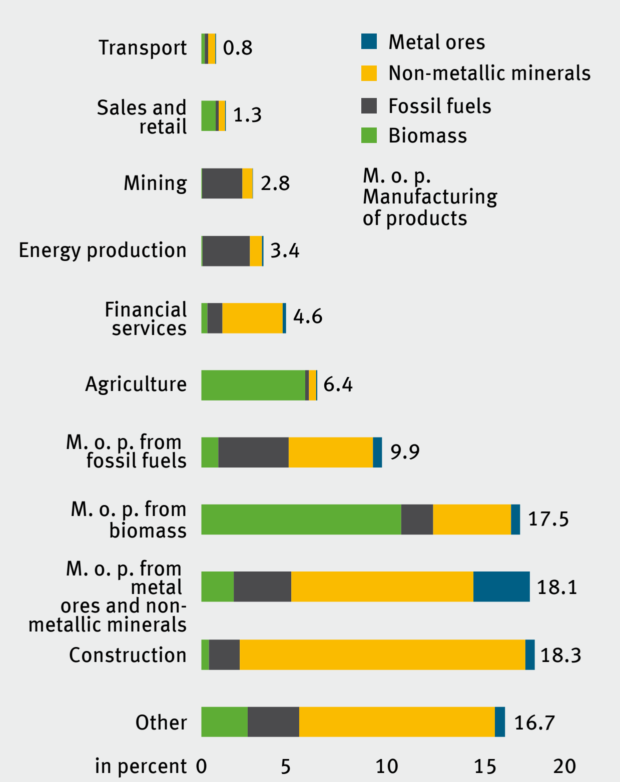


Figure 33 Source: WU, 2017 a

Public and private consumption

Public and private consumption were jointly responsible for almost two-thirds of raw material consumption in Germany in 2014. With regard to private consumption, large quantities of raw materials were consumed in the consumption areas of housing and food. The public sector's requirements for raw materials occurred primarily via the consumption of goods and services in the areas of administration, defense and health. The state's relatively high share in Germany's overall consumption reflects the key importance of the welfare state's role in the country.

The raw material consumption (RMC) of German final demand can be subdivided into different groups. These are: (1) consumption, (2) construction activities, (3) equipment and other infrastructure (4) changes in stocks (Fig. 34). Consumption" is additionally divided into private households, the state and private non-profit organisations, such as associations or political parties. The raw material requirements of the economy, by contrast, are not included in final demand.

In 2014, the raw material consumption of final demand in the "consumption" group amounted to almost 797 million tonnes. Construction activities accounted for 629 million tonnes. Examples for this are the construction of new railroad lines or highways. Equipment and other infrastructure comprised 107 million tonnes in total. Stock changes and net increases of goods showed a decrease of roughly 200 million tonnes. In other words, more goods were sold than were produced.

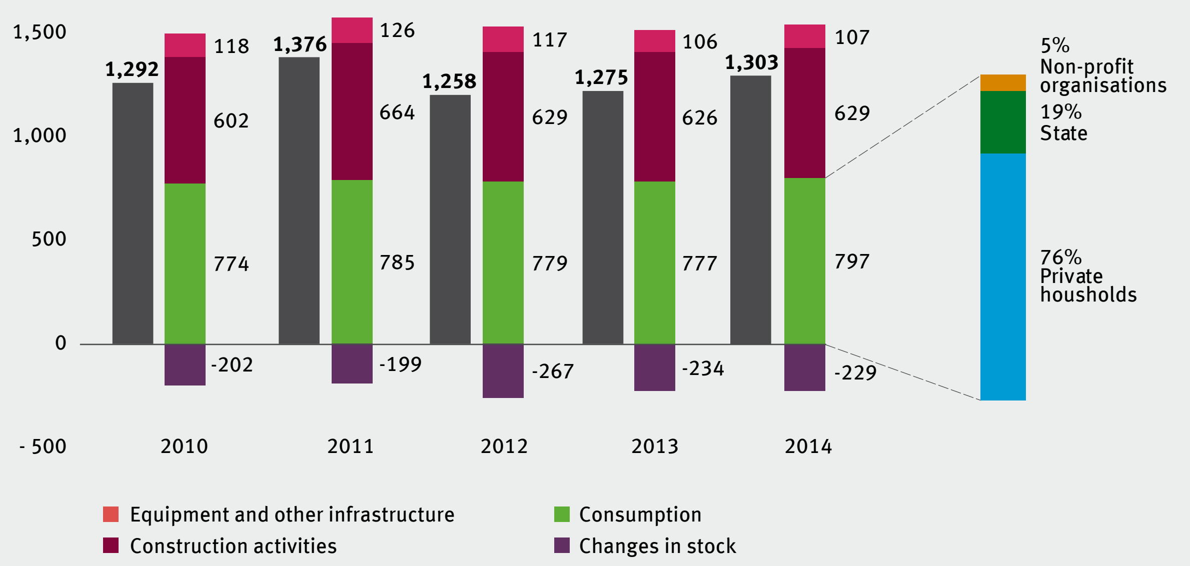
Within the "consumption" category, the consumption of private households had the major share, with more than three-quarters of total consumption (76 %), followed by the state (19 %) and private non-profit organisations (5 %) (WU 2017a).

In comparison to the previous years, the relationship between the individual areas remained almost unchanged. However, the apparent decrease in total RMC between 2011 and 2012 (pp. 42/43, "Composition and trends of final demand") is reflected in all categories of final demand, although this is particularly the case in construction. In the succeeding years to 2014, "Consumption" in particular increased once again.

Private and state consumption together account for more than 60 % of RMC in Germany. The previous UBA Resource Report 2016 already examined in detail the extent to which this raw material consumption can be attributed to different consumption and output fields (pp. 52/53, UBA Resource Report 2016). Housing and food were by far the most raw material-intensive consumption areas in 2014, each accounting for almost one-third (32 % and 31 %) of total raw material consumption by private households. Leisure activities occupied the third place in 2014, accounting for 19 % of the total (Fig. 35).

In comparison, the resource requirements of public administration were lower. "Public administration, defense and social security" constituted the largest share with 54 % of the state's RMC. "Public health and welfare services"

Trend of raw material consumption of final demand in Germany by category, 2010–2014



Numbers underlying the right part of the figure are based upon calculations carried out with the model EXIOBASE 3.3.
Calculations by the German Statistical Office (Destatis) do not allow to disaggregate raw material consumption into sub-categories.

Figure 34 Sources: Destatis, 2018; WU, 2017 a

Private and public raw material consumption in Germany by consumption area, 2014

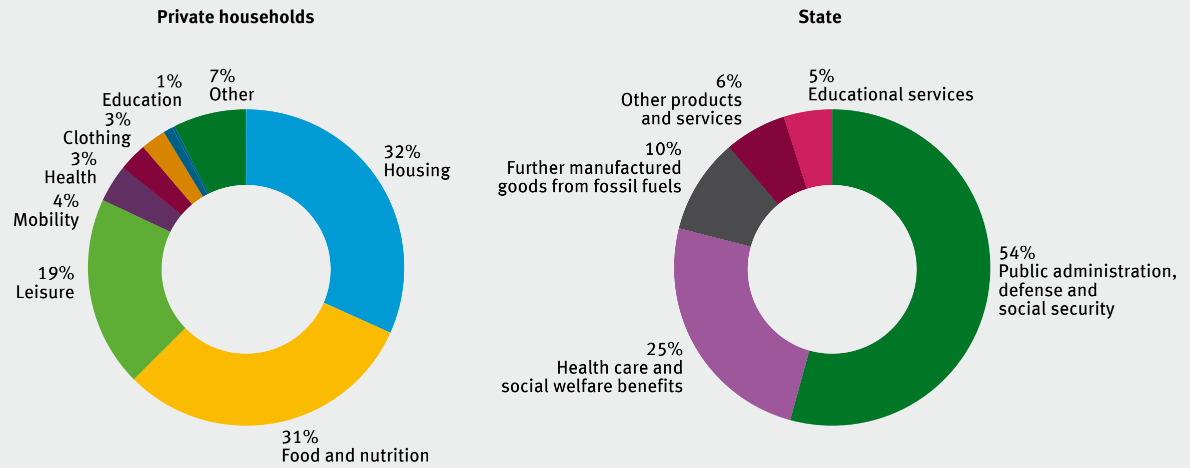


Figure 35

Source: WU, 2017 a

consumed 25 %. In the case of health, in addition to the raw material consumption by the state and private households also other areas contributed to overall consumption (↘ pp. 48/49, "The example of health").

Internationally, the contribution of final demand categories to total RMC varies significantly (↘ Fig. 36). There is particular variation between the shares of private and public consumption, as well as of investments in infrastructure. At 13 %, the share of public consumption in Germany is higher than in the USA (10 %), China (8 %) or Brazil (2 %). In contrast, the contribution of private consumption in Germany in 2014 was lower (49 %) than in Brazil and the United Kingdom (UK) (62 % each), although far higher than in China (20 %) and Indonesia (33 %). These differences reflect the design of the welfare state and the role of different social actors. The stronger the welfare state, the more important is the role of the state and thus of public raw material consumption. Conversely, the more is invested in infrastructure by the private sphere or by private companies commissioned by the state, the larger is the share of capital investments.

Compared with other countries, it is thus evident that the state plays a relatively important role in Germany, taking over many functions for society as a whole. In China's rapidly growing economy, by contrast, capital investments for developing infrastructure in the areas of energy, transport and construction are predominant. In Brazil, private households consume the most, while the state has only a marginal contribution to consumption of 2 %.

International comparison of raw material consumption of final demand by share of individual categories, 2014

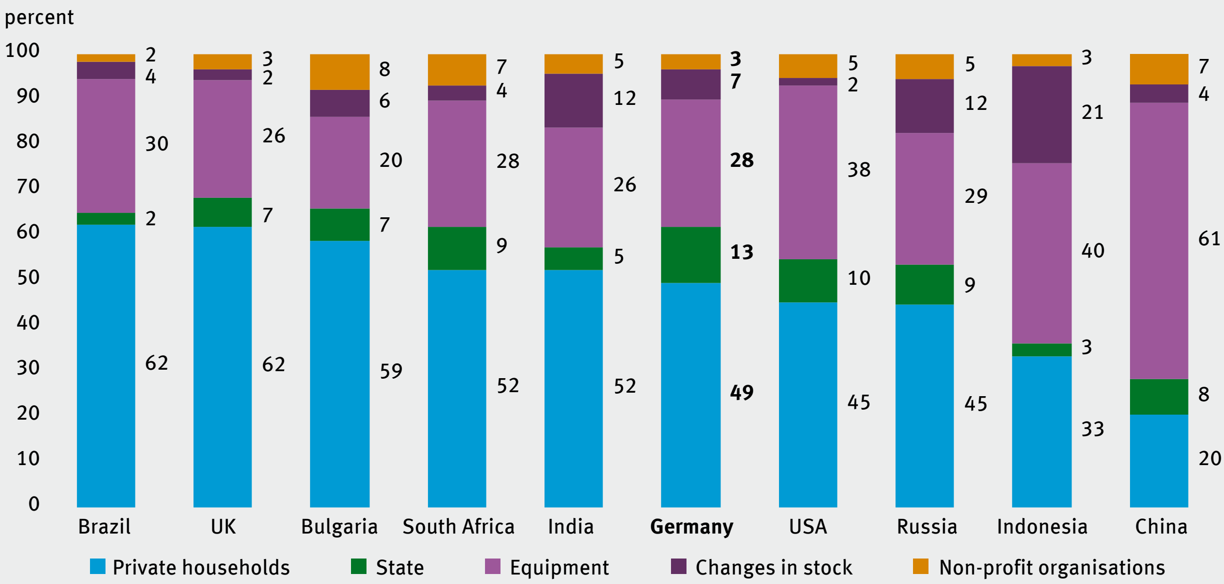


Figure 36

Source: WU, 2017 a

Raw material consumption by consumption areas: The example of food

In 2014, average household spending in Germany on food was 455 Euro per month. This was linked to raw material consumption of approximately 558 kg per household, most of which was based on biomass as the basic component of foodstuffs. The production of individual foodstuffs varies greatly, however, in terms of the material intensity involved.

Following housing, food is the second most raw material-intensive area of private consumption in Germany. While food also plays an important role in the public arena, such as in public administration or the hospital sector, private households are the primary consumers of raw materials in this consumption area.

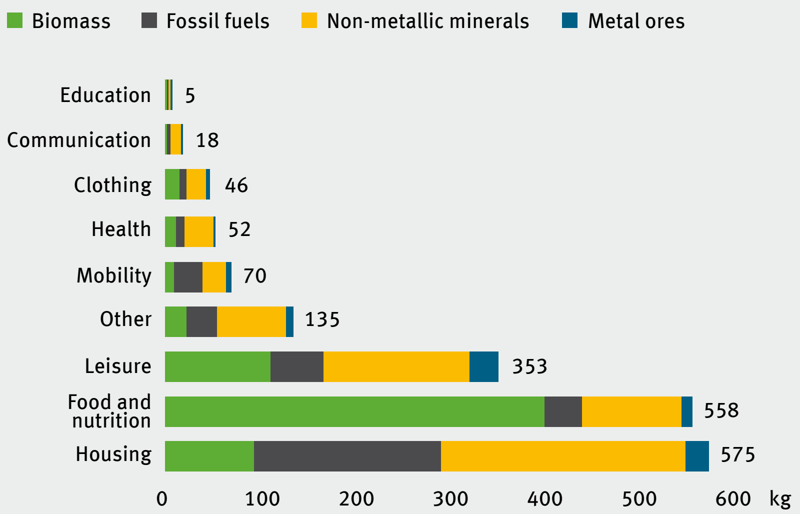
Including all those raw materials that were input both within and outside the country along the value chains of foodstuffs consumed within Germany, 269 million tonnes of raw materials were required to feed the country's households in 2014. This represents a monthly value of 558 kilogrammes for an average household. The value for housing as a consumption area is only slightly higher, at 575 kilogrammes per month, while the value for leisure activities is markedly lower, at 353 kilogrammes monthly (↘ Fig. 37).

As expected, the consumption area of food is primarily (72%) based on biomass as a basis for foodstuffs. However, the manufacture of food products also involves other raw materials as indirect inputs. Production chains require fossil fuels(7%) for the operation of agricultural machinery or to heat or cool greenhouses and food storage facilities. In addition to this, non-metallic minerals (19%) and metal ores (2%) are required to manufacture these machines and facilities.

A comparison between raw material consumption and monetary spending in the various consumption areas (↘ Fig. 37) is instructive. "Food and nutrition", comprising the consumption of foodstuffs, drinks, tobacco as well as hospitality, was the second most important aspect of monthly household spending after housing and amounted to 455 Euro per month on average in 2014 (Destatis, 2017f). Although almost one-third (31%) of raw material consumption was linked to food, the share in overall household spending was less, at just under one-fifth (19.2%). By contrast, housing accounted for 41.6% of spending. This means that one Euro of spending on food is significantly more raw material-intensive than a Euro spent on housing. If we consider the various food products consumed (↘ Fig. 38), it is evident that the largest share of raw material consumption for food in 2014 comprised inputs into the production of meat and dairy products, 24% or 63 million tonnes. 34 million tonnes were input into the production of oils and fats (12%). At 27 million tonnes, cereals accounted for 10% of raw material consumption in the area of food.

The high share of meat and dairy products can be attributed to the fact that animal products are extremely raw material-intensive due to the high demands for feedstuffs in the livestock sector and associated infrastructure requirements. Also, large areas are required for cultivating fodder

Monthly raw material consumption and spending per private household in Germany, by consumption area and product group, 2014



	Raw material consumption		Expenses	
	kg	percent	Euro	percent
Education	5	0.3	17	0.7
Communication	18	1.0	61	2.6
Clothing	46	2.5	107	4.5
Health	52	2.9	92	3.9
Mobility	70	3.9	325	13.7
Other	135	7.5	82	3.5
Leisure	353	19.5	248	10.4
Food and nutrition	558	30.8	455	19.2
Housing	575	31.7	988	41.6
	1,994		**2,375**	

Changes in relation to the UBA Resource Report 2016 are less attributable to changes in consumer behaviour and far more to the further development of the EXIOBASE calculation model.

Figure 37

Sources: Destatis, 2017f; WU, 2017a

Trends of raw material consumption linked to foodstuffs consumed in German households by product group, 1995–2014

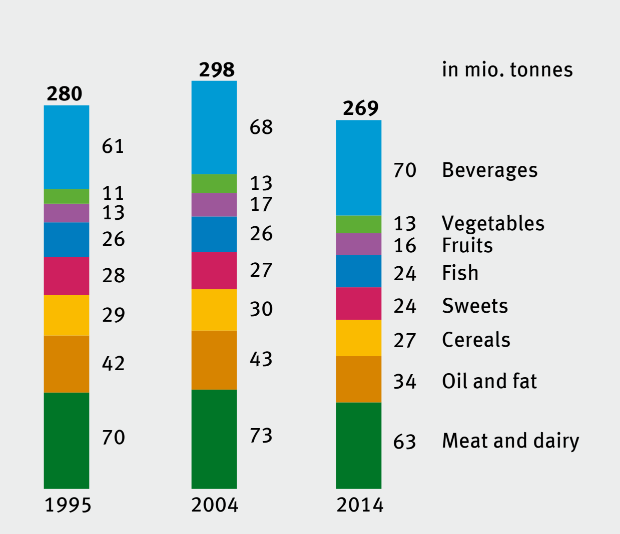


Figure 38 Source: WU, 2017a

plants. Cereals, vegetables and fruits, in contrast, can be consumed directly, yet they – and indeed all foodstuffs – also require raw materials for harvesting machinery, storage, transport and distribution.

Raw material consumption in the area of food has undergone marked fluctuations in the past (↖ Fig. 38). Thus it increased between 1995 and 2004 from 280 million tonnes to almost 300 million tonnes. Increasing quantities of raw materials flowed into the consumption of meat and dairy products in particular during this period. This category of foodstuff did, however, exhibit the strongest decrease in the years that followed. Over 10 years (2004–2014), the raw material consumption of meat and dairy products fell by 10 million tonnes or 14%. There may be various reasons for this; for example, a change in the eating habits of the German population, or in the sources of foodstuffs towards more industrial production methods. The consumption of oils and fats and also cereals fell significantly too. This reduced the raw material consumption related to food overall by 10% (1995–2014).

Regarding the overall trend relating to increasing consumption of biomass, across all sectors (↖ pp. 42/43, "Composition and trends of final demand"), it may hence be concluded that this is largely attributable to the increased use of biomass in the non-food sector. This includes, for example, agrofuels and wood-based products, such as paper or textile fibres.

Human nutrition serves to fulfil our daily energy and thus our calorific requirements. On average, an adult requires 2,000–2,500 kilocalories (kcal) per day (Schweizer Nährwertdatenbank, 2017). This requirement can be fulfilled with varying efficiency depending on the selected foodstuff (↘ Fig. 39). Whereas 1.6 kg of pork would supply the daily calories required, an adult would require 4.5 kg of apples or 11 kg of tomatoes to obtain the same calorific intake.

However, not only the relationship between mass and energy value but also that between mass and the actual raw material inputs into production are important here. In this respect, meat production is associated with far higher consumption of raw materials. Yet a marked difference is also evident in respect of other resources too (↘ Fig. 39). Per kilogramme of beef, almost 80 kilogramm of raw materials are required for feed, animal husbandry and processing. The water required to supply daily needs with pork or beef would amount to between 9,400 and almost 28,800 litres, whereas for tomatoes it would be 2,500 litres and for apples, 3,700 litres. The choice of specific diets therefore has not only health but also environmental consequences and thus represents an important instrument for the personal resource management.

Comparison between different food products according to nutritional value and resource input to supply the calories required for a daily intake of 2,500 kilocalories

	Pork	Beef	Tomatoe	Cheese	Apple	Rice	Potatoe
Kilocalories per 100g	160	134	21	400	55	119	77
Resource input to supply the daily intake of 2,500 kilocalories:							
Weight in kg	1.6	1.9	11.9	0.6	4.5	2.1	3.2
Blue and green water in litres	9,400	28,800	2,500	2,000	3,700	5,200	900
CO_2 emissions in kg	6.6	22.9	9.2	3.6	1.1	6.4	1.3
Total material input in kg	28.9	79.5	111.9	25.1	7.7	no data	6.5

Figure 39 Sources: Kauppinen et al., 2008; Mekonnen and Hoekstra, 2011; ifeu, 2016; Schweizer Nährwertdatenbank, 2017

Raw material consumption by consumption areas: The example of health

Large quantities of raw materials are used directly and indirectly to satisfy the requirements of the health sector. In 2014, 101 million tonnes of raw materials were required to fulfil all the services of the health sector in Germany. State-run health services accounted for the largest share, at 54 %. Raw material consumption by the health sector in Germany has risen by 69 % since 1995.

Together with the construction industry and the area of food, services such as health care (hospital stays, medication, medical engineering, etc.) are also an important driver for Germany's consumption of raw materials and resources. In 2014, the raw material consumption of private households, the state sector (including care) and of private non-profit organisations within the health sector amounted to 101 million tonnes (↘ Fig. 40).

This raw material consumption arises from the manufacture of goods, such as medication and cleaning products, and the provision of services in the health sector, such as health insurance services. In addition to these, the raw material inputs for construction of hospitals and health facilities is included. The largest share in raw material consumption in the health sector is accounted for by the state (54 %), followed by private non-profit organisations – for example, religious associations (34 %) – and private households (12 %). In this context it must be noted that consumption expenditure by the state in the area of health includes on one hand state-run services that serve public health interests and on the other hand, those that target consumption by individuals. The latter include, for example, subsidies for recovery/rehabilitation and also individual components such as covering the costs of medication. The raw material consumption related to these services appears in connection with the purchaser of such services (i.e. the state) and not with the consumers.

The 101 million tonnes of raw materials consumed directly and indirectly in Germany in 2014 go along with almost 330 billion Euro in health spending, which represents about 10 % of GDP (Destatis, 2017 g). These expenditures are realised by the state directly, by obligatory and private health insurance as well as by employers and private individuals.

In the health sector, raw material consumption by the state increased during the period 1995–2014 by more than half (54 %), while that of private non-profit organisations increased by 67 %. The strongest overall increase, however, was seen in the health-related raw material consumption of individual households – i.e. by 79 %. Although the boundary between the state and private households is hard to define precisely where health is concerned, it is nonetheless evident that there was an overall increase in health-related raw material consumption of 69 %. Strikingly, only a slight increase was observed during the period 2011–2014.

Due to the large number of goods and services used, the health sector has a very complex supply chain structure where all material groups are used as input. This includes

Trends of raw material consumption of the health sector in Germany by categories of consumption, 1995–2014

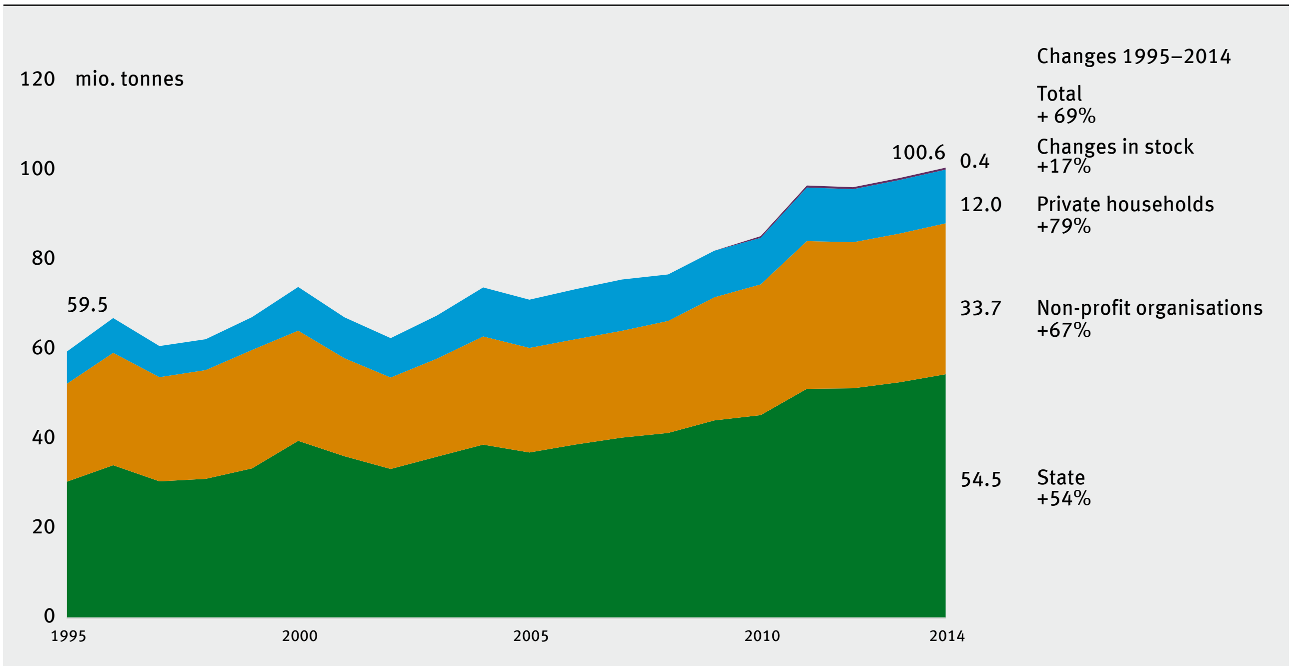


Figure 40

Source: WU, 2017 a

Share of upstream services of the health sector and social care services in Germany in the sector's total raw material consumption, 2014

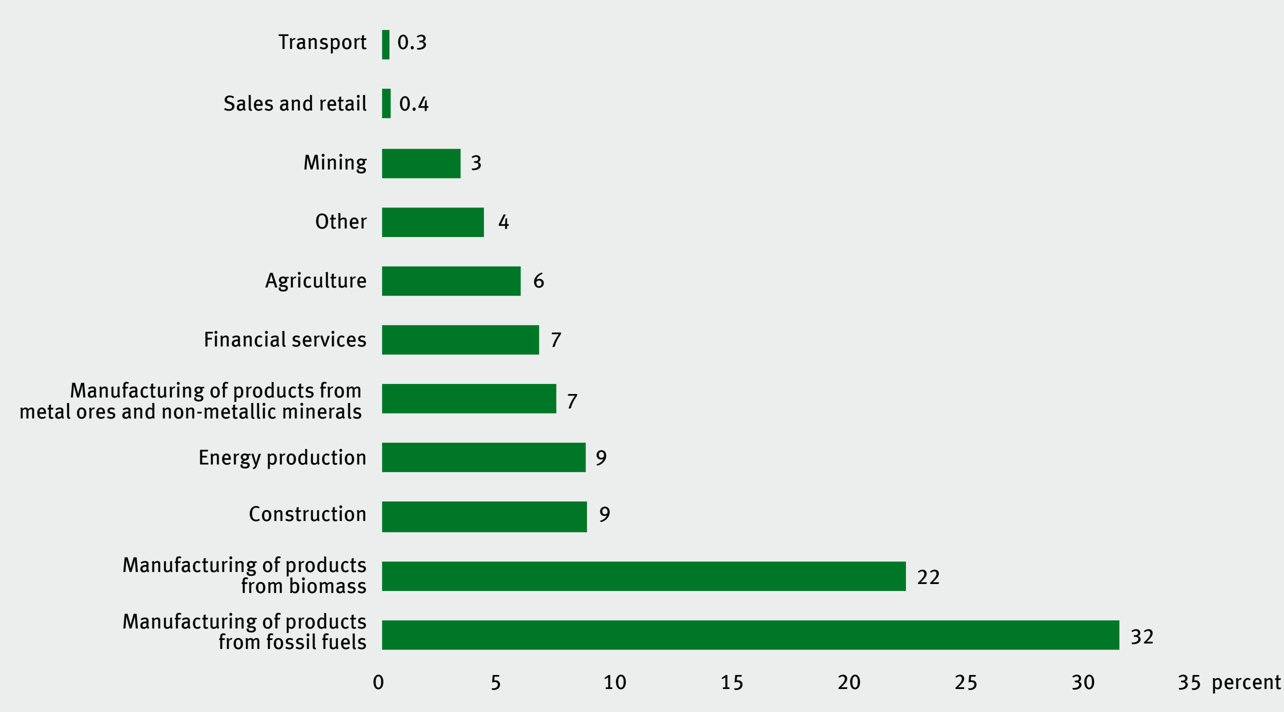


Figure 41 Source: WU, 2017 a

products from fossil fuels, particularly chemical products (medication, cleaning products, single-use clothing, plastic containers, etc.), and metal products (medical and optical instruments) together with biomass (food supplies, ethanol). Energy is also required, as well as financial services, e.g. through credit arrangements (Fig. 41).

In 2014, products based on fossil fuels accounted for 32 % of the total raw material consumption of the health sector, followed by products based on biomass (22 %) and energy products (9 %), as well as construction industry-related products (9 %). A comprehensive strategy for raw materials management in the health sector must therefore focus on these areas in particular – for example, by means of efficient use of cleaning products or avoiding food waste.

The trend for outsourcing the raw material base concerns service sectors as much as it does sectors in manufacturing industry. Thus services such as the health sector are – even if indirectly – characterised by an increasing dependency on raw materials coming from abroad.

About 65 % of the fossil fuels required for the provision of the German healthcare system's services originated abroad. In the case of biomass consumed, this share was 67 %, while 69 % of non-metallic minerals and 100 % of the metal ores required came from outside Germany (Fig. 42).

When focusing on a single sector such as health,it is important to note that the upstream services involved are extremely complex and that assumptions and simplifications have to be made when categorising individual products or supply chains (pp. 10/11, "Methodological background"). Furthermore, the figures provided for raw material consumption encompass entire supply chains, which – as already noted – often have their starting point located abroad. It is therefore only partly possible to exert influence directly on the ways in which they are structured.

Origin of raw material base for the German healthcare system, 2014

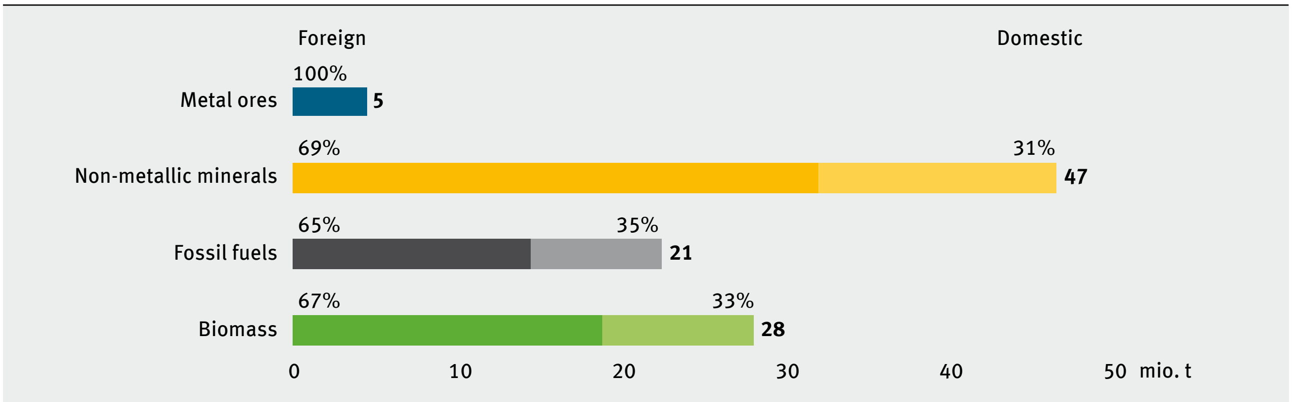
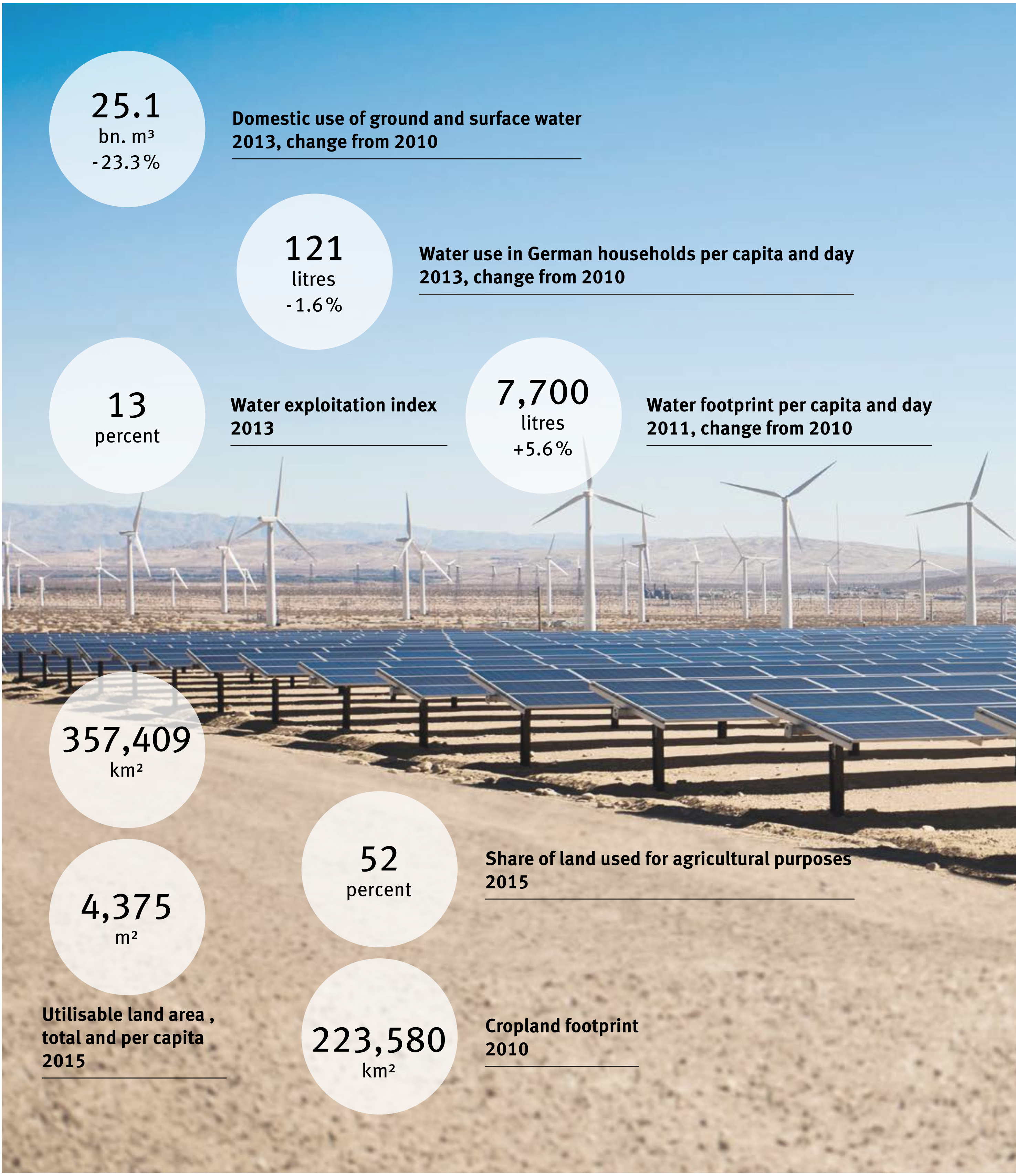


Abb. 42 Source: WU, 2017 a

Other natural resources



25.1
bn. m^3
-23.3 %

Domestic use of ground and surface water
2013, change from 2010

121
litres
-1.6 %

Water use in German households per capita and day
2013, change from 2010

13
percent

Water exploitation index
2013

7,700
litres
+5.6 %

Water footprint per capita and day
2011, change from 2010

357,409
km^2

4,375
m^2

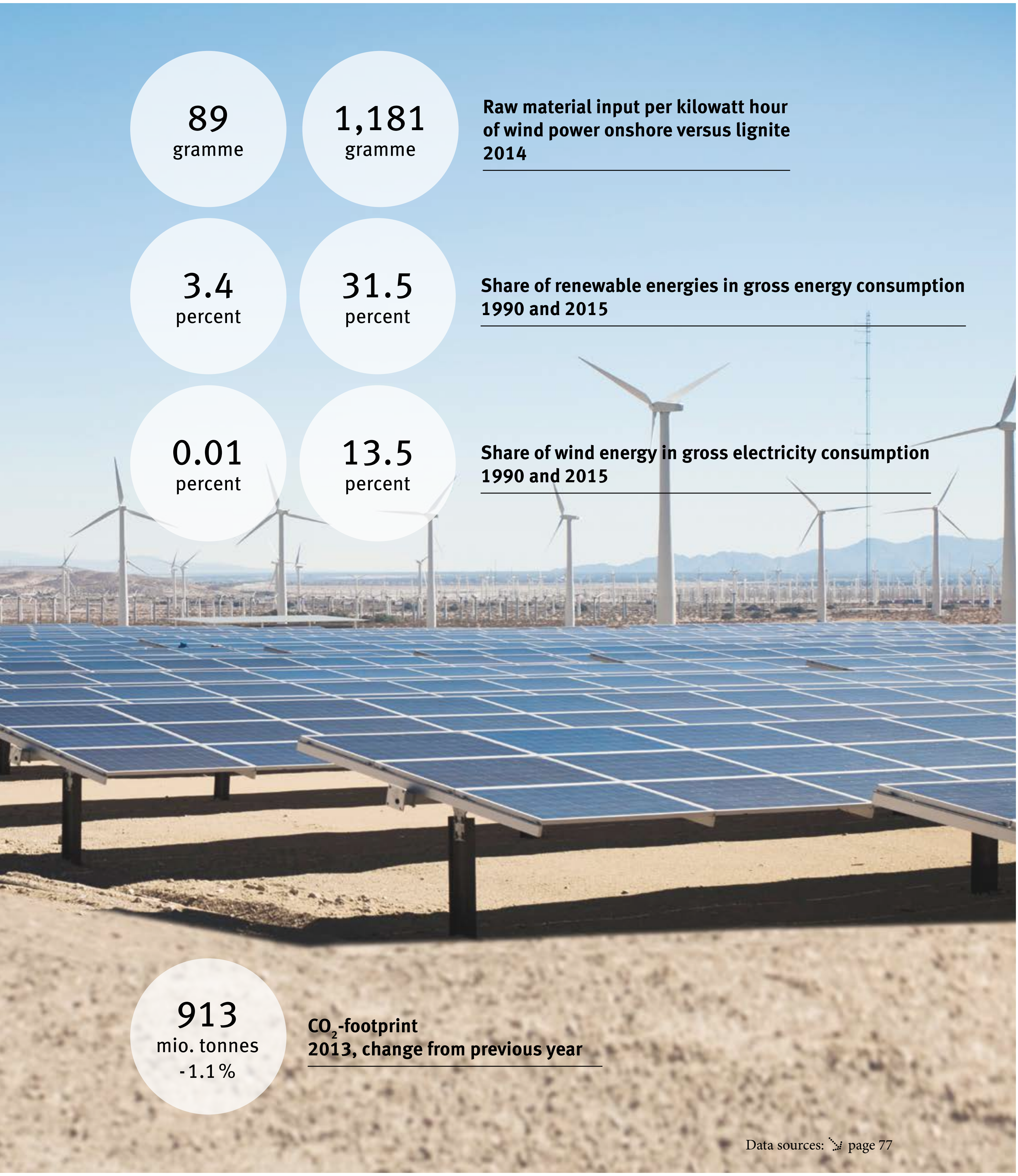
Utilisable land area ,
total and per capita
2015

52
percent

Share of land used for agricultural purposes
2015

223,580
km^2

Cropland footprint
2010



89 gramme | 1,181 gramme

Raw material input per kilowatt hour of wind power onshore versus lignite 2014

3.4 percent | 31.5 percent

Share of renewable energies in gross energy consumption 1990 and 2015

0.01 percent | 13.5 percent

Share of wind energy in gross electricity consumption 1990 and 2015

913 mio. tonnes -1.1 %

CO_2-footprint 2013, change from previous year

Data sources: page 77

Water use and water footprint

Germany is a country rich in water resources. About 13% of the annual renewable water resources were abstracted in 2013. Hence, the German water exploitation index was below the critical value of 20%. Alongside the water use of private households, economic activities utilise the greatest quantities of water. Water is used for the production of energy and for the extraction of raw materials, for example in mining and agriculture. While water abstraction in Germany was almost halved between 1991 and 2013, the quantity of water indirectly consumed through imported products rose.

In 2013, a total of 25.1 billion cubic metres of water were abstracted in Germany for use by industry and in private households (Fig. 43). Energy generation accounted for the largest share, with 13.6 billion cubic metres (54%) being used in thermal power plants, followed by mining and manufacturing industries with 6.1 billion cubic metres (24%), and public water supply with 5.1 billion cubic metres (20%). Agriculture accounted for only 1% of the total abstraction.

Since 1991, water abstraction in Germany has been sharply reduced. It fell from 46.3 billion cubic metres to almost half that figure in 2013. Energy generation played a significant role in this development, where water use was reduced by 53% through decreasing the abstracted quantity of cooling water. Reductions in water abstraction were also significant in the mining and manufacturing industries (-44%) and thus also contributed to the overall trend towards reduction.

With renewable water resources of 188 billion cubic metres, Germany is a land rich in water resources (BfG, 2016). The water resources are composed of precipitation and evaporation depth as well as of the inflow/outflow balance. In order to identify whether a country is suffering from water shortage or water stress, the water exploitation index (WEI) was developed. It compares figures for water abstraction with those for available water resources. If the value is above 20%, a country or region is determined as suffering from water stress, and a value of more than 40% indicates an severe stress level.

In 2013, the water exploitation index in Germany was 13% and thus indicated the country was not in a situation of water stress. The long-term trend for Germany since 1991 shows the water exploitation index has fallen significantly, from 25% to 13%. It has only achieved a value below the water stress level of 20% since 2004. The water resources available in Germany are however subject to regional and seasonal differences. Precipitation and evaporation, together with groundwater recharge, vary from region to region. For instance, the federal state of Brandenburg has markedly less precipitation than Baden-Württemberg (UBA, 2017b).

Following abstraction from surface waters or groundwater bodies, water is distributed for various uses. For example, 3.5 billion cubic metres i.e. 121 litres per capita and day, are distributed by the water supply sector to households and small businesses. Alongside the analysis of water abstraction quantities, monitoring of water flows between the environment and the economic system is also possible. Water actively abstracted from surface waters and groundwater flows into the economic system. Rainwater and infiltration water (e.g. ground water infiltrating the wastewater/drainage system) are also accounted for as flows from the environment to the economy. Infiltration water creates an undesired outflow in drainage systems (Fig. 44). Almost 5 billion cubic metres of rainwater and infiltration

Water extraction by economic sector in Germany, and share in renewable water resources, 1991–2013

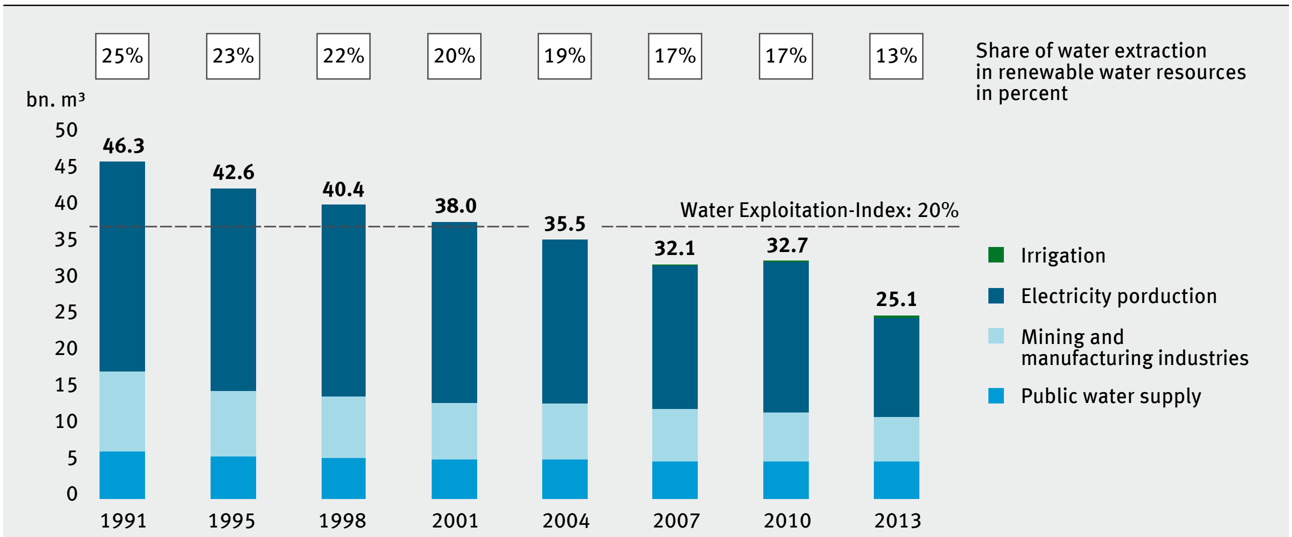


Figure 43 Source: Destatis, 2016c

Water flows from nature to the economy in Germany, 2013

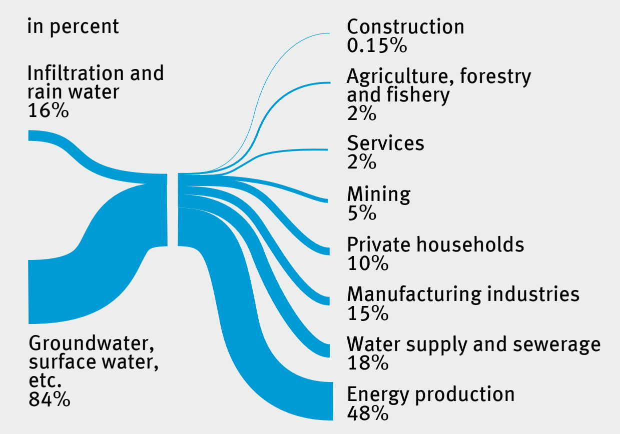


Figure 44 Source: Destatis, 2017 a

water thus create additional inflow into the water drainage and sewerage system.

Many sectors use water for the supply, production and processing of goods destined for export. Thus water is also used in other countries for the production of goods imported into Germany. The total quantity of water that is used inside and outside Germany to create goods for German final demand is defined as the "water footprint" (pp. 58/59, UBA Resource Report 2016). It is subdivided into a blue (surface and groundwater) and a green (rainwater) component (pp. 10/11, "Methodological background"). A consumption-oriented approach to the analysis of water use in Germany must take account of both the domestic water input and the water footprint.

The water footprint can be calculated using different methods. If a global economy-environment model is used, Germany's water footprint in 2011 was 226 billion cubic metres. This represents an increase of 21 % since 1995 and equates to a volume of 2,810 cubic metres per capita and year. Germany's water footprint is thus many times larger than the water quantity that is abstracted in Germany itself. By way of comparison: while in private households in Germany 121 litres of water per capita and day are used directly, the water footprint per capita and day is 7,700 litres.

In 2011, the foreign share in the total water footprint of Germany was 67 %. A particularly important role regarding indirect water quantities imported to Germany was played by Asian countries, especially China, India and Indonesia, but also by Brazil and the USA (Fig. 45). Those countries, in which the water requirement for agriculture is largely naturally covered, show higher flows of green water into Germany. These countries include China, India and Brazil. China and India, however – together with the US – also show a high level of irrigation and thus contribute as well to the blue water footprint of Germany.

Over time, the role of individual countries and regions as indirect water suppliers has changed. Thus, India plays an increasingly important role with continually growing green and blue water flows to Germany. China and Brazil export particularly large quantities to Germany, although this reduced slightly during the period observed (1995–2011). In the case of Brazil, however, the share of irrigated exports as a proportion of total exports increased steadily.

Germany's net imports of blue and green water, 2011*

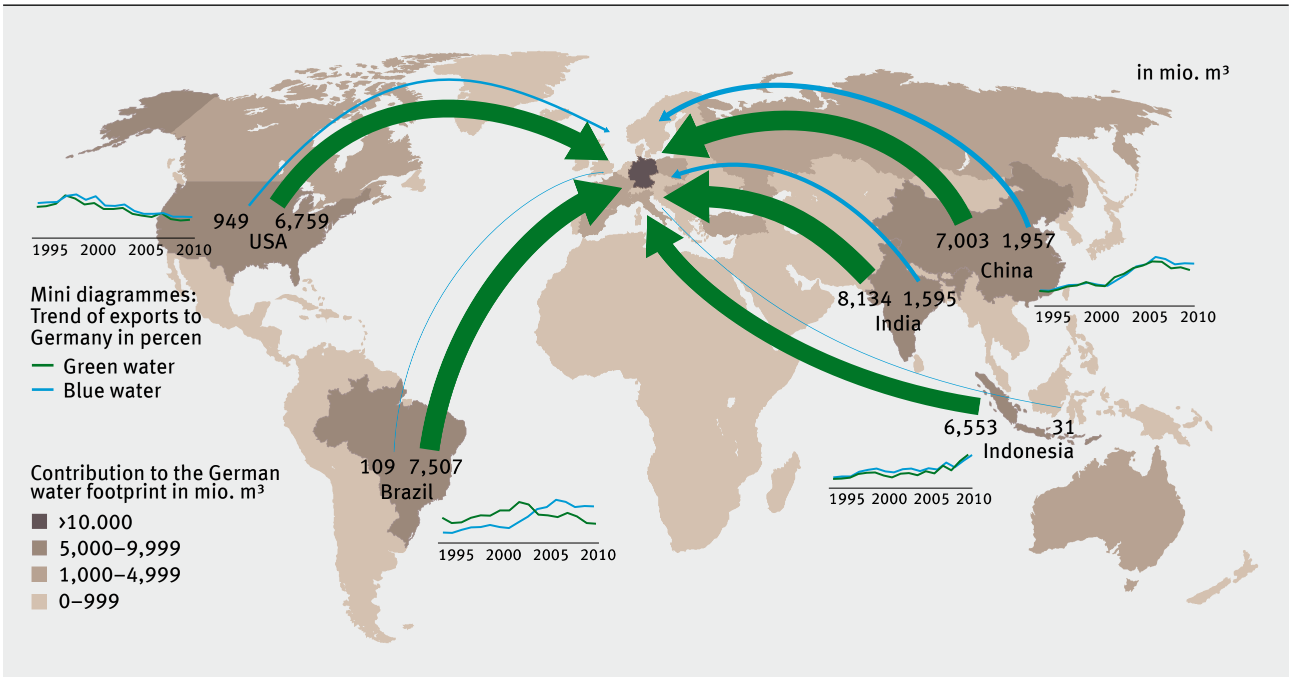


Figure 45 Source: WU, 2017a

* Water footprint calculations were undertaken using the multi-regional input-output model EXIOBASE 3.3. Because of the further development of this model in comparison to the previous version, the figures provided here differ from those of the UBA Resource Report 2016 (pp. 10/11, "Methodological background").

Land use in Germany

Alongside raw materials and water, land is another important natural resource utilised by humans. Germany has a land area of 357,409 km². In 2015, over 80 % was covered with fields, pastures and forests. Residential areas and transport infrastructure covered about 14 %, with an increasing trend. However, land sealing and intensive agriculture are limiting the capacity of land areas to function as part of the ecosystem.

Germany's utilisable land area in 2015 amounted to 357,409 km² (Destatis, 2016 d). This represented around 0.4 hectares per inhabitant or 227 inhabitants per square kilometre. By way of comparison: the country with the highest population density in Europe (excluding micro-states), the Netherlands, has a population density of 411 inhabitants per square kilometre.

In 2015, 184,332 km², and thus more than half (52 %) of Germany's land area, was used for agricultural purposes, followed by 109,515 km² of forest land (31 %). The remaining types of land use accounted for a relatively small share in the total: built-up areas and open spaces together with transport infrastructure only covered 12 % of Germany's land area in 2015. Other uses played a marginal role in numerical terms (Fig. 46). Altogether, residential areas and transport infrastructure accounted for 14 %. This distribution of land uses had barely altered in comparison with the previous reporting year, 2013 (pp. 60/61, UBA Resource Report 2016).

From a long-term perspective, forest land grew by almost 5 % between 1992 and 2015. Built-up areas increased in the same period by 21 %, while land area used for transport infrastructure increased by 10 %. Most of these developments involved land previously allocated to agricultural use, which diminished by 6 %.

Land use and its alterations can be better understood and analysed by employing greater geographical differentiation. In this context, there is a far more variable picture at the scale of individual federal states (Fig. 47). In 2015, the share of agricultural land was greatest in Schleswig-Holstein (70 %), followed by Mecklenburg-Vorpommern (62 %). Rheinland-Pfalz and Hessen, at just over 40 %, had the smallest share of agricultural land. In absolute terms, those federal states with the highest extraction of renewable raw materials (pp. 24/25, "Raw material extraction by the federal states"), i.e. Bavaria and Lower Saxony, also have the largest share in total agricultural land in Germany, at 33,106 and 28,510 km², or 18 % and 15 % respectively.

The federal states with the largest share of forest land were Rheinland-Pfalz and Hessen, each having more than 40 % forest cover. This equates to 8,477 and 8,367 km² respectively. In absolute terms, Baden-Württemberg and Bavaria had the largest areas of forested land in Germany as a whole, at 13,698 and 25,707 km² respectively.

If one considers the share of land used for residential areas and transport infrastructure, North Rhine-Westphalia was in first place with 20 %, followed by Saarland (20 %) and Hessen (15 %). In Germany as a whole, Bavaria, North Rhine-Westphalia and Lower Saxony together contained almost half of all land used for settlement and transport purposes.

Land sealing is an important factor in the context of sustainable use of land as a resource in Germany. Soil or land sealing through construction, asphalting and other forms of stabilizing surface treatment destroy the natural fertility of the soil and prevent future (re-)use of land for forestry and agriculture. As a result of the increasing share of residential areas and transport infrastructure mentioned above, an average of 66 hectares of land was sealed each day in 2015 (UBA, 2017 c). Although this is a significant improvement on the average for the period 1993–1996 (120 hectares/day), further measures are needed if the federal government is to meet its own targets of reducing the rate of increase in residential areas and transport infrastructure to 30 hectares per day by 2020 (Deutsche Bundesregierung, 2016 a; BMUB, 2016). Examples of such measures include land recycling in the case of fallow land or the use of new mechanisms, such as a system of tradable land permits (UBA, 2015 c).

Also agriculture has a crucial role to play in achieving more sustainable land use in Germany. Organic farming is one way of achieving this, yet it is still significantly under-represented in German agriculture. Notwithstanding, the number of organic farming businesses more than tripled between 1996 and 2015, when there were 24,736 such farms (Fig. 48). In that year, organic farming accounted for more than 10,000 km², and thus for 6.5 % of total agricultural area. This overall increase slowed somewhat in

Land use in Germany by type of usage, 1992 – 2015

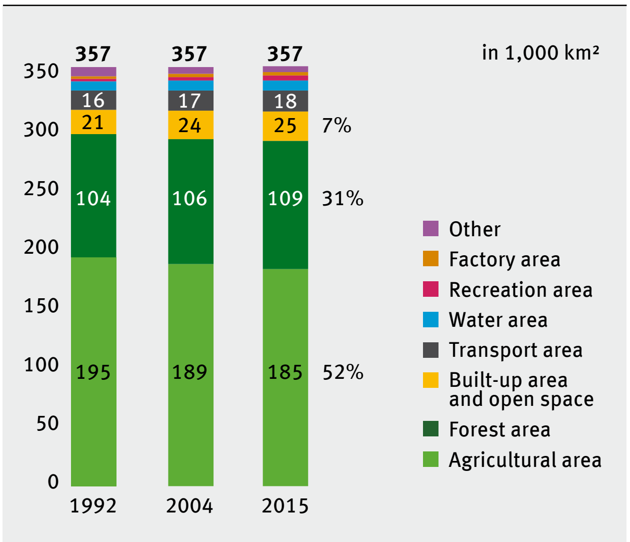


Figure 46 Source: Destatis, 2015 b

Shares of land use for different purposes by federal state, 2015

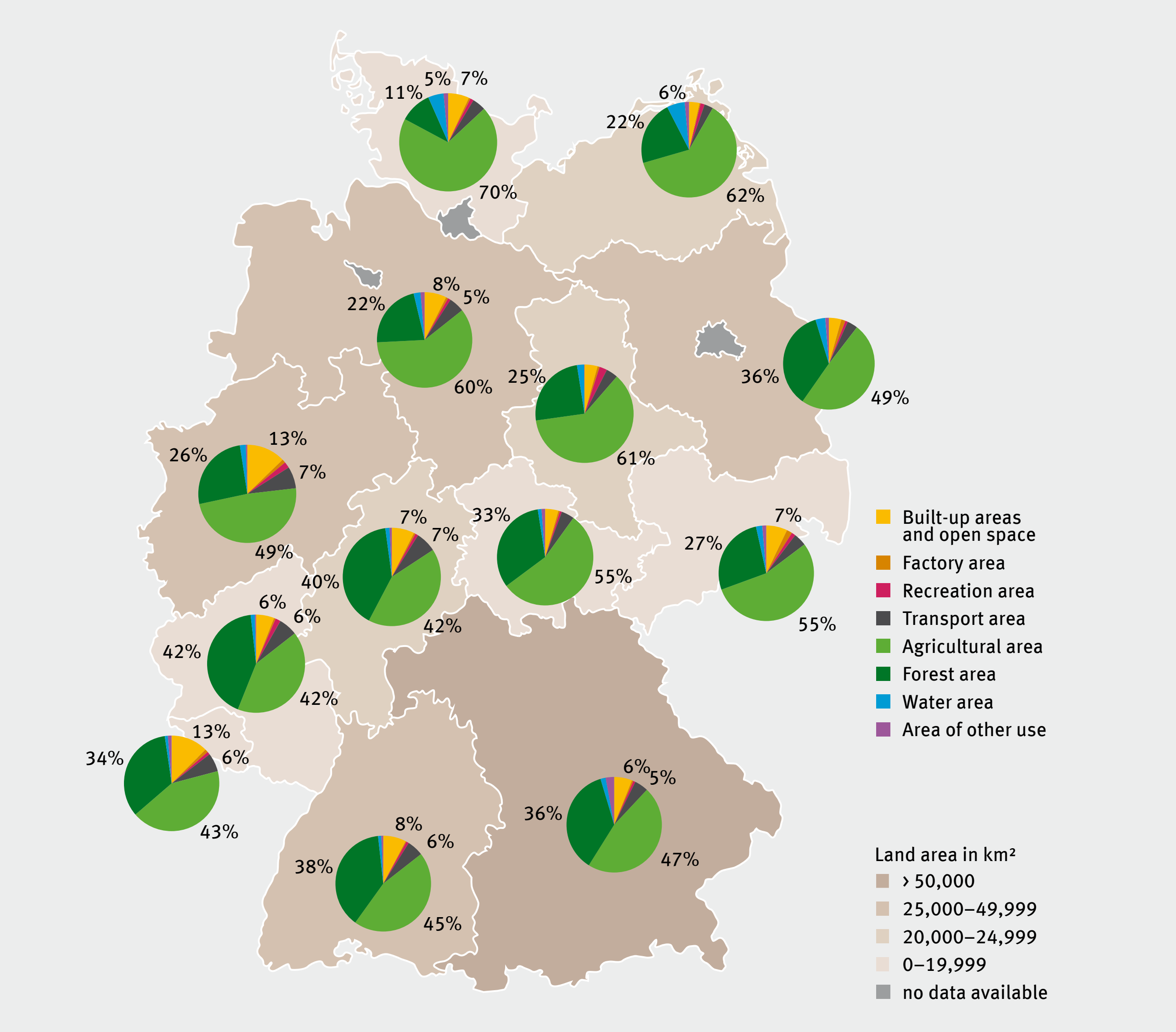


Figure 47 Source: Destatis, 2016d

recent years, however (BMEL, 2017). The federal government set itself a mid-term goal in the context of the "Organic Farming: Looking Forwards" strategy (BMEL, 2017): to increase the share of land used for organic farming to 20% of the total agricultural land. Based on current trends, however, this goal would take a number of decades to be achieved.

Organic farms and area utilised by organic farming in Germany, 1996–2015

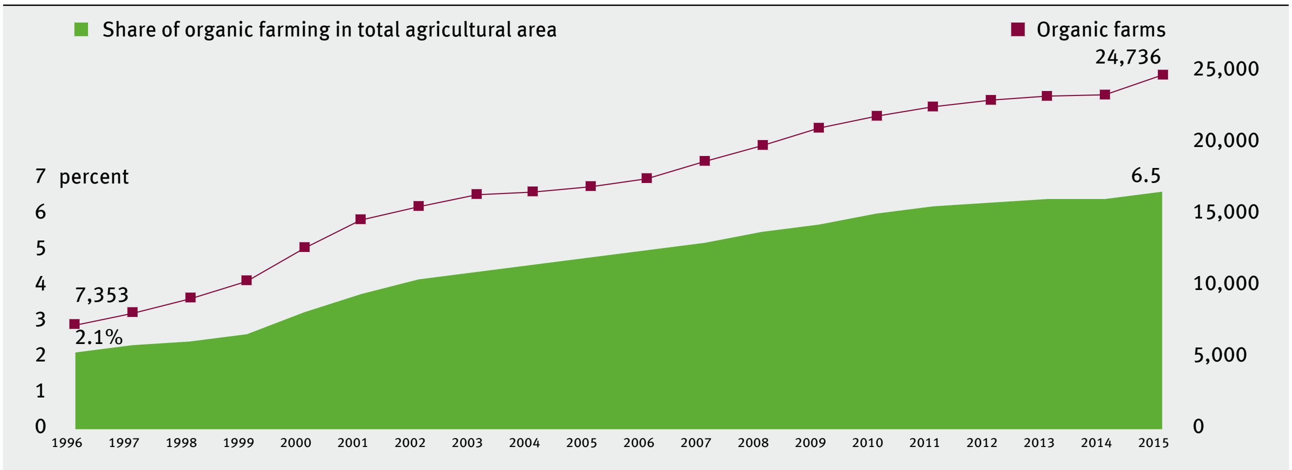


Figure 48 Source: BMEL, 2017

Germany's land footprint

In addition to domestic land use, Germany also utilises significant amounts of land beyond the country's borders. The so-called land footprint is constituted by all the land areas used in and outside the country to produce the goods that are consumed in Germany. Depending on the category, the share of land use that is located abroad can be as much as 68 %.

63 % of the biomass that is consumed either directly or indirectly by German final demand originates abroad (pp. 28/29, "The geographical origin of raw materials"). To supply this biomass, large land areas are required. The sum of all land areas that are required both in and outside a country for the production of all the goods consumed within that country is termed the "land footprint". This is an indicator of the resource and area use required for agricultural and forestry products and is subdivided into three major categories: cropland, grassland and forest land (UBA, 2013). The land area that is used in Germany to create export products is allocated to the countries importing those products. That means, that the domestic share of Germany's land footprint is not equivalent to Germany's utilisable land area.

Calculating methodologies of the land footprint differ for the three land footprint categories and are so far only applicable for 2010, given the current availability of data (Bruckner et al., 2017). For this reason, it is not possible to add the three categories together to create a total footprint. Nonetheless, by contrasting the three land footprints, the importance of foreign land with regard to all three categories becomes clear (Fig. 49). This share is largest (68 %) in the case of the forest land footprint, which amounted to 29.4 million hectares in 2010. The grassland footprint was 13.7 million hectares, of which 66 % were situated abroad. And in the case of cropland almost half (47 %) of the 22.4 million hectares consumed were located outside Germany. The country's consumption is thus – as in the case of raw materials and water - highly dependent on land resources abroad. This means that it also indirectly shares responsibility for the negative impacts of land use, such as deforestation or loss of soil nutrients.

Domestic and foreign share of Germany's land footprint by category, 2010

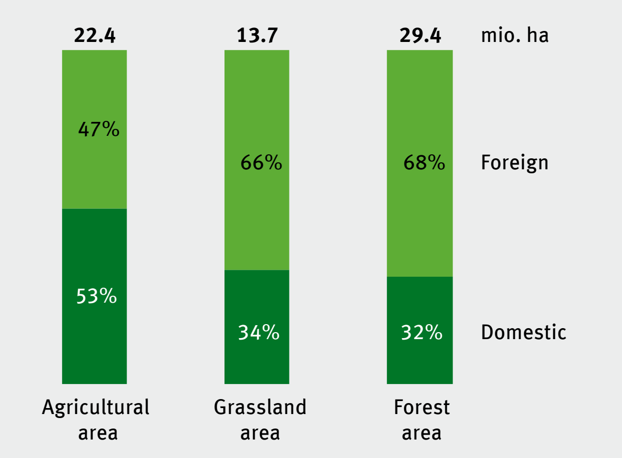


Figure 49 Source: Bruckner et al., 2017

The cropland footprint refers to the area required in and outside Germany to satisfy demand for agricultural products for food and animal feed as well as for non-food use. This amount remained roughly constant, albeit with a slight decrease from 22.6 to 22.4 million hectares (Fig. 50). The cropland footprint was thus significantly larger than the entire land area used for agricultural purposes in Germany, which amounted to 18.7 million hectares and included both cropland and pasture land (grassland).
It is evident that the land requirements for plant-based food decreased, while the land requirements for non-food products such as plant fibres or oils, simultaneously increased by 27 %. In 2010, the share of the latter in the total cropland footprint was already as high as 24 %. And this share is expected to continue to grow, as in other areas too, such as plastics, increasing use is being made of renewable raw materials. This development also reflects the growing importance of the bioeconomy.

As a trading nation, Germany not only imports large quantities of cropland but it exports them too. 24 million hectares of imports, primarily in the form of vegetable oils, cereals and tea or cocoa, were accompanied by exports and re-exports from German agriculture and industry totalling 13.6 million hectares; the latter primarily in the form of meat and dairy products. In other words, Germany is a net importer of virtual cropland (Bruckner et al., 2017). If one traces the various trade flows back to their origin and to the geographical location of cropland, an interesting difference appears between food and non-food products. Whereas the requirement for food products in Germany is covered to about 60 % by domestic cropland, and a further 23 % lie within the EU, 86 % of the non-food products of biotic origin that are consumed in Germany are produced on cropland abroad, primarily (40 %) in Asia.

In addition, significant quantities of wood-based products – for example paper or furniture – are consumed in Germany. Thus here too, forest land indirectly flows into the land footprint's overall balance. In 2010, the forest land footprint amounted to almost 30 million hectares and was thus nearly three times the size of the entire forest area in Germany itself (10.8 million hectares).

Long-term trends exhibit marked fluctuation. From 36.5 million hectares in 1995, the forest land footprint increased to almost 41 million hectares in 2000. 85 % of the total was industrial timber and only 15 % was wood used to generate energy. After 2000, the forest land footprint fell to about 29 million hectares, before increasing

Germany's cropland footprint, 1995–2010

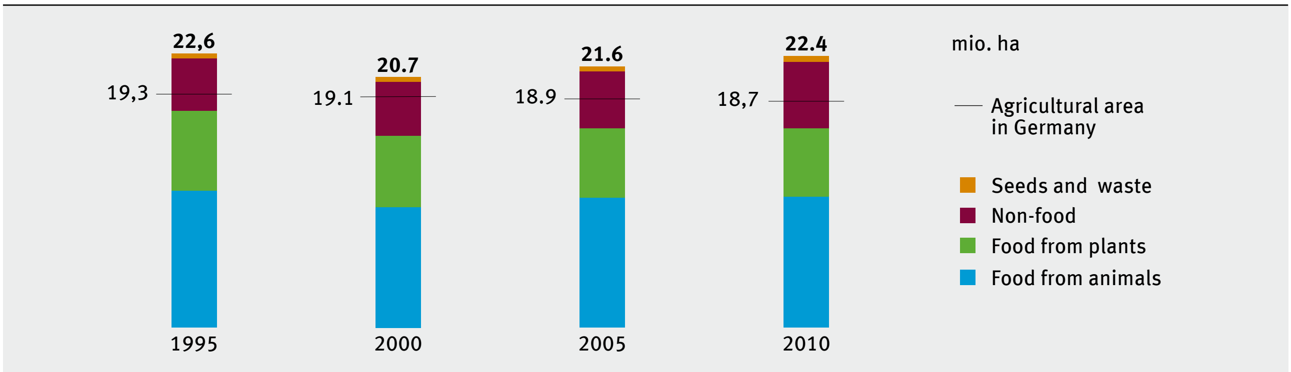


Figure 50 Source: Bruckner et al., 2017

slightly in 2010. The significant decrease of 30% between 2000 and 2009 was accounted for by all the sectors, in which wood is an important raw material, e.g. wood processing, furniture and paper production together with printing and publishing. Also with regard to construction activities, the direct and indirect use of wood decreased from 2000 onwards.

About two-thirds of Germany's forest land footprint originates abroad. About 17% of forest land used were in another EU state in 2010 and about 19% were in another European state, e.g. Russia. Less than 10% respectively of the forest land consumed in Germany were located on other continents – North America (9%), Latin America (8%), Africa (7%) and Asia (9%) (↘ Fig. 51).

Land-based footprint indicators are effective in determining the indirect requirements of land areas through consumption. In particular, they show the enormous scale of German consumption in quantitative terms and the claims thereby made upon land areas in other parts of the world. Footprint indicators are however not capable of describing specific environmental impacts, since, for example, the varying intensities of respective land uses are not considered. They are also unable to provide information on aspects such as productivity and the quality of land use, which are significant for an integrated assessment. One option to provide a more comprehensive perspective would be to extend the land footprint to include the deforestation or soil quality impacts related to the respective land areas (Bruckner et al., 2017).

Another important link exists between the land footprint and water footprint (↖ pp. 52/53, "Water use and water footprint"), since in most parts of the world, agricultural activities are extremely water-intensive. In many cases, increases in cropland footprint in particular are associated with increased pressure on local water resources. Growing competition for land as a resource is thus often closely coupled with competition for water resources.

Geographical origin of Germany's forest land footprint, 2010

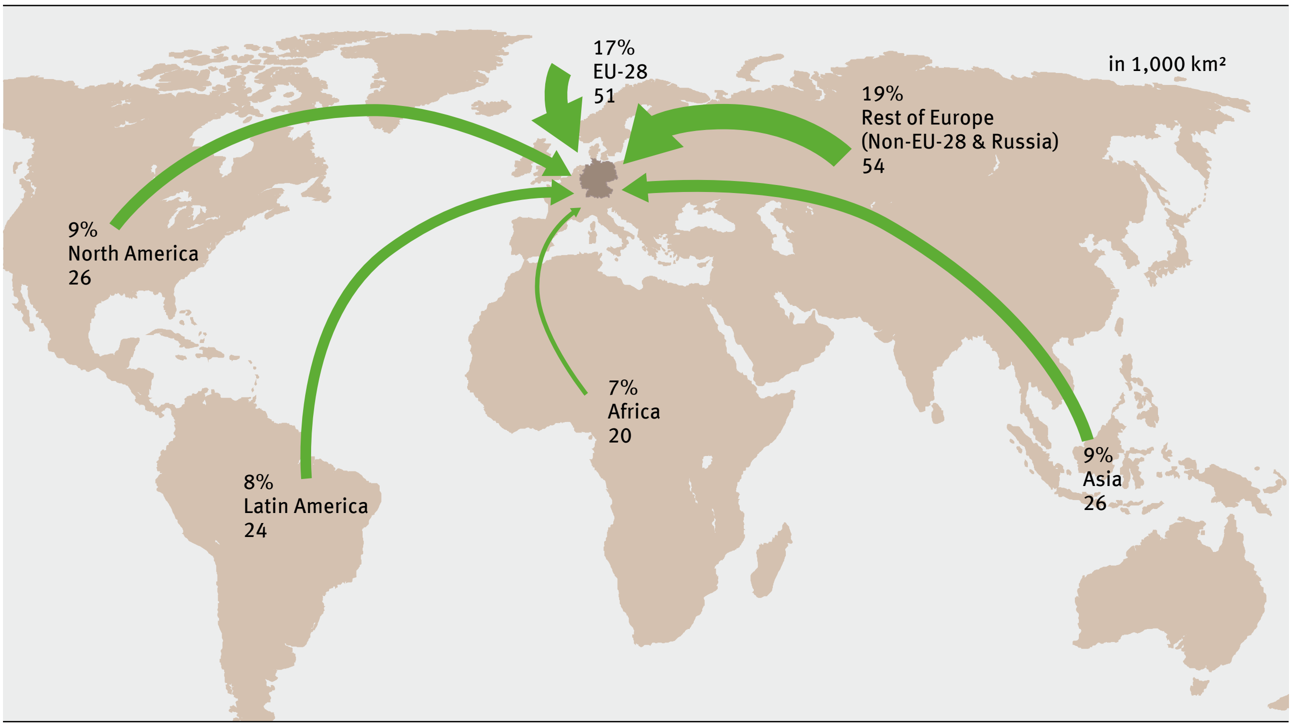


Figure 51 Source: Bruckner et al., 2017

Flow resources

In 2015, flow resources such as wind, sun, water and other renewable energy carriers accounted for 12.4 % of primary energy consumption in Germany, and for as much as 31.5 % of gross electricity consumption. Trends show strong increases since 1990. Flow resources are an important alternative to fossil fuels and make an important contribution to climate protection and the preservation of natural resources. Despite this, the use of renewable energies is also linked to a demand for non-renewable raw materials, albeit with far lower material intensities than is the case for fossil fuels.

Flow resources comprise solar energy, wind power, geothermal energy and water. They belong to the renewable natural resources (↘ pp. 62/63, "Glossary"). Together with biomass and waste products, they play an increasingly important role as renewable energies or alternative energy sources.

In 2015, the share of renewable energies in the total primary energy consumption of Germany was 12.4% (↘ Fig. 52). This represents a slight increase in comparison to the previous year. In 1990, the share was only 1.3%. Solid and gaseous biomass combined with wind energy play a particularly important role in satisfying primary energy consumption. They accounted for more than two-thirds of the contribution made by renewable energy sources.

Looking just at gross electricity consumption in Germany, the share of renewables has also risen significantly since 1990 (3.4%), accounting for 10.2% by 2005 and reaching 31.5 % in 2015. At 13.5 %, electricity from wind energy accounted for the largest share of gross electricity consumption, followed by electricity from biomass (7.3%) and photovoltaics (6.5%). Fossil fuels and nuclear energy continue to form the largest share in electricity consumption (67%).

The energy concept of the federal government provides important support for the expansion of renewable energies in Germany. The so-called "Renewable Energies Act" (BMWI 2014) sets a target of increasing the share of renewable energies in gross electricity consumption to 40–45% by 2025 and to at least 80% by 2050. The share in gross final energy consumption is intended to increase to 60% by 2050 (UBA, 2017 d). By that means, especially harmful greenhouse gas emissions will be reduced by 80 to 95% by 2050, in comparison to the base year 1990.

The German Environment Agency (UBA) has already spent several years investigating ways of achieving still more ambitious goals for climate protection in Germany. It was demonstrated as early as 2010 that electricity generation from 100% renewable energy sources was possible (UBA, 2010). The study entitled "Treibhausgasneutrales Deutschland im Jahr 2050" ("Greenhouse gas-neutral Germany in 2050") (UBA, 2014) proved that the technology would allow for Germany to be largely greenhouse gas-neutral, with an annual per-capita emission of one tonne $CO_{2\text{-eq}}$ by 2050, which would equate to a reduction in emissions of about 95% in relation to 1990 figures. A recent study by the UBA also sets out the pathways to achieving a greenhouse gas-neutral Germany and conserving natural resources (UBA, 2017 e).

At the European level, the EU Member States have agreed an energy strategy for 2030, which sets targets to reduce CO_2 emissions by 40% in comparison to 1990 figures and to increase the share of renewable energies across Europe by

Contribution of renewable energies to primary energy consumption, and share in gross electricity consumption, gross final energy consumption and primary energy consumption, 1990–2015

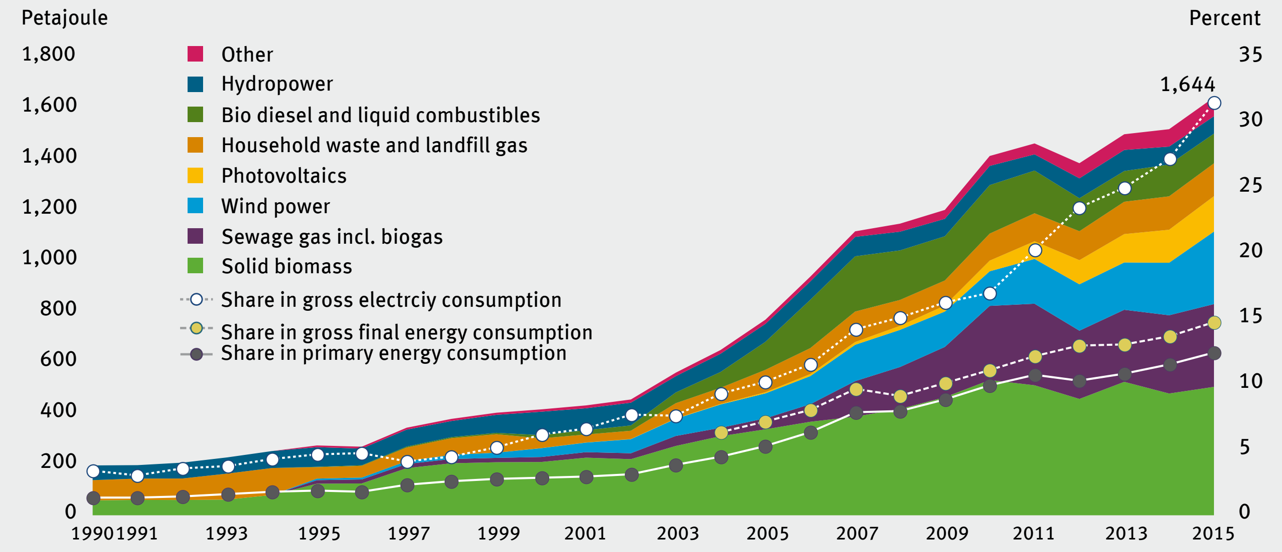


Figure 52

Source: BMWI, 2017, 2018

Primary energy generation from renewable energies in Europe, 2015

Petajoule TOP-10 Country	Biomass and Waste	Hydro-power	Wind energy	Solar energy	Geo-thermal energy	Total	Share in gross final energy con-sumption [%]
Germany	1,098	68	285	168	9	1,628	14.6
Italy	450	164	53	91	229	987	17.5
France	583	196	76	30	9	895	15.2
Sweden	439	271	59	1	0	769	53.9
Spain	293	101	178	133	1	706	16.2
Turkey	135	242	42	35	202	656	13.6
Norway	50	496	9	0	0	555	69.4
UK	298	23	145	29	0	495	8.2
Finland	366	60	8	0	0	435	39.3
Austria	226	133	17	11	1	390	33.0

Table 1 Source: EUROSTAT, 2017

27 % as well as achieving energy savings of up to 27 % (European Commission, 2014).

In 2015 alone, wind energy installations were erected across Europe with a generating power of 12.8 gigawatts (Wind Europe, 2018). Also in Germany, 2015 was a peak year, with an additional wind energy capacity of 6 gigawatts installed. In absolute terms, renewable energies contributed more than 1,628 petajoule to final energy consumption in Germany. This puts Germany at the top of the league table, followed by Italy (987 PJ) and France (895 PJ) (↖ Table 1).

Raw material input (RMI) and unused extraction (material) for selected electricity generation options in grammes per kilowatt-hour of electricity produced

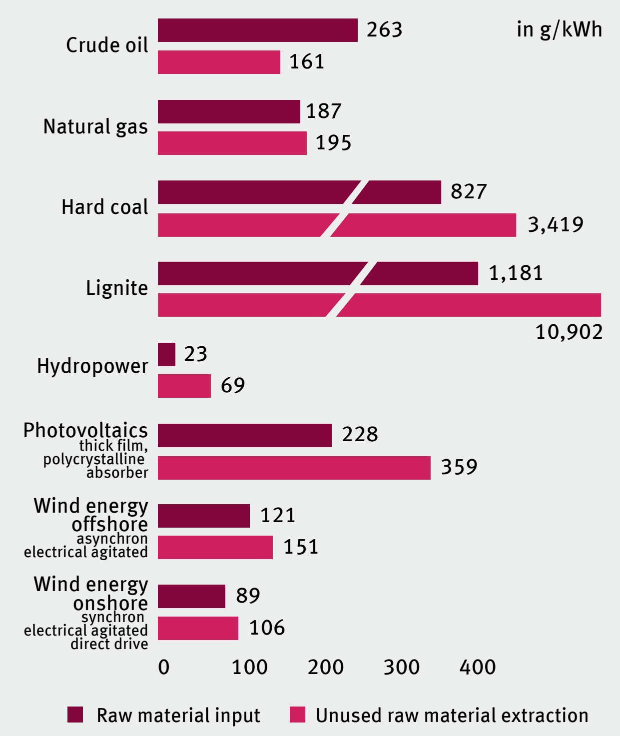


Figure 53 Source: Wiesen et al., 2017

While Germany leads the way especially in the electricity sector with regard to the use of wind energy (285 PJ) and solar energy (photovoltaics and solar thermal energy, 168 PJ), Italy and Turkey are the leading users of geothermal energy (229 PJ and 202 PJ respectively). Sweden and Norway, however, have the largest share of renewable energies in gross final energy consumption because of their advantageous geographical conditions. While Germany at almost 15 % lies in the range of the EU average in this respect, and thus far below the EU target, Norway and Sweden have already achieved a share of 70 % and 54 % respectively due to their significant hydropower resources and the use of local biomass.

The use of renewable energies such as wind, water and sun makes a significant contribution to climate protection, but also to the conservation of resources. In contrast to fossil fuels and their energy conversion processes, renewables are linked to far lower resource use, since there is almost no involvement of energy carriers such as coal, oil and natural gas.

Nonetheless, the expansion of renewable energy is linked to energy and material requirements. The construction of power plants and the related infrastructure requires significant amounts of minerals. For instance, rare metal ores such as selenium and neodymium are required for the production of magnets, but also large quantities of iron, copper and aluminium are used. The raw material inputs for a single wind turbine with a generating capacity of 3 mega-watts can be up to 2,000 tonnes, while the components themselves, such as steel, concrete, copper or aluminium, also have an "ecological material rucksack" (⇢ pp. 62/63, UBA Resource Report 2016). However, in comparison with conventional electricity production, which is dependent on high levels of fossil fuels inputs, the material intensities and raw material inputs respectively of renewable systems per kilowatt-hour of electricity produced are considerably lower, particularly when compared with energy generation using coal (↖ Fig. 53).

Raw material use and climate change

The environment performs important sink functions, such as binding emissions or filtering wastewater. Since the extraction, processing and transport of raw materials and the use of products are all associated with significant energy inputs, greenhouse gas emissions occur along the entire value chain of raw materials. The use of raw materials and climate change are thus closely interlinked. It becomes evident that increasing the efficiency of raw materials use is an essential prerequisite for reaching climate goals.

The UBA Resource Report 2016 highlighted the fact that the environment is not only an important source of raw materials but also functions as a sink for the national economy and consumption in Germany. (⇢ pp. 64/65, UBA Resource Report 2016). In connection with the use of raw materials, the greenhouse gas emissions (GHG) thereby produced and their contribution to climate change play an important role – i.e. the use of the atmosphere as a sink. For this reason, this section focusses on the interrelationships between raw material use and climate change.

Current calculations by the International Resource Panel of the United Nations show that the ambitious climate goals of the Paris Agreement can only be achieved with a significant increase in raw material efficiency resulting in a reduction of emissions produced during extraction and processing, as well as of those associated with land use. Achieving the internationally agreed climate goals without improving resource efficiency is not only far harder but above all much more expensive (UNEP, 2017).

In 2015, direct emissions in Germany amounted to 907 million carbon dioxide equivalents, which were largely created by the use of fossil fuels such as coal or oil. This represented a slight reduction of 0.3 % from the previous year. 85 % of the emissions were produced during energy generation, 7 % each by industry and agriculture.

In connection with the successor agreement to the Kyoto Protocol, which was signed at the end of 2015 during the UN climate conference in Paris, Germany set itself the target of reducing emissions by 40 % by 2020 and becoming largely greenhouse gas-neutral by 2050 (↖ pp. 58/59, “Flow resources”). While a reduction of 28 % was recorded between 1990–2014, a slight increase in greenhouse gas emissions was observed in the years that followed. Current estimates see again a small decrease in 2017 (UBA, 2017 f; UBA and BMU 2018).

As in the cases of raw materials, water and land, also with regard to GHG a consumption-based perspective has to be applied by accounting for the indirect CO_2 emissions. Current figures from Destatis show that the CO_2 footprint of German final demand was 913 million tonnes in 2013. Both imported and exported quantities of emissions rose during the period, whereby exports of emissions exceeded the imports. This negative trade balance resulted in the CO_2 footprint being lower than the direct emissions of 942 million tonnes (↘ Fig. 54).

Changes in direct climate emissions and the carbon footprint of Germany, 1990–2015

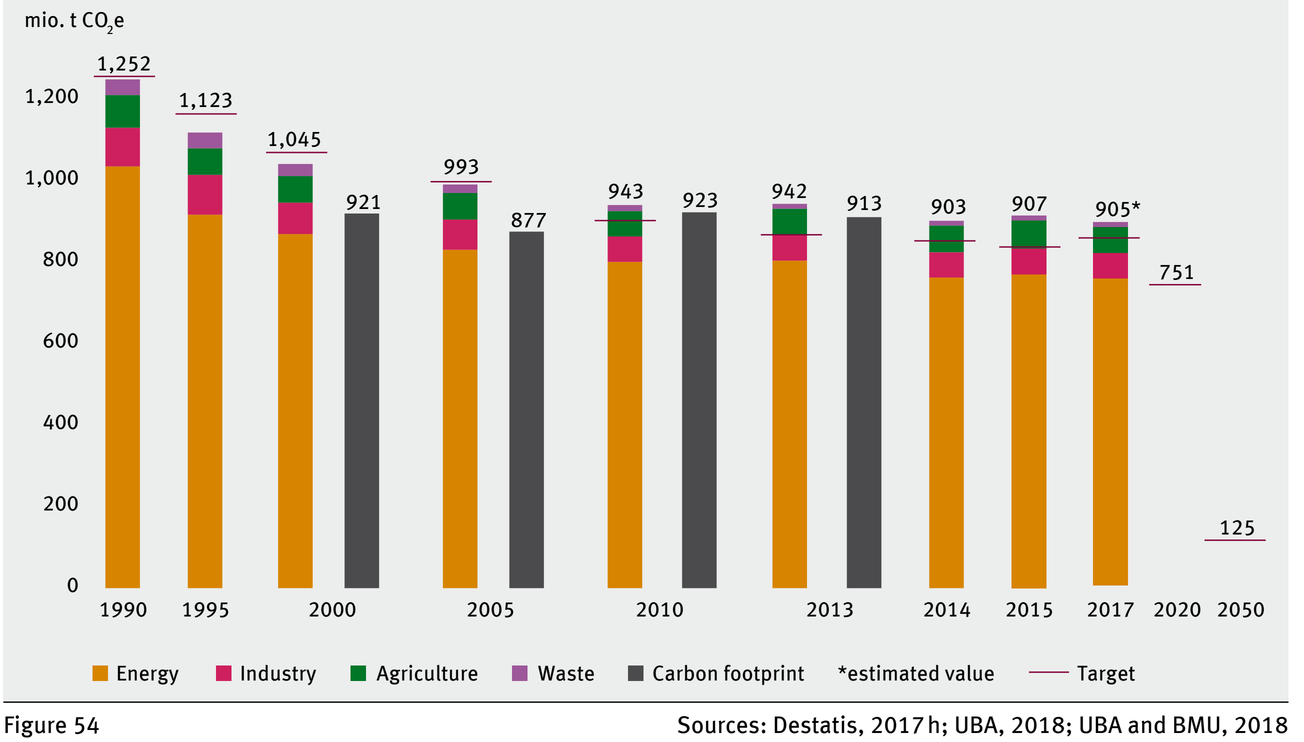


Figure 54 Sources: Destatis, 2017 h; UBA, 2018; UBA and BMU, 2018

Development of raw material consumption (RMC) and the carbon footprint of Germany, 1995–2012

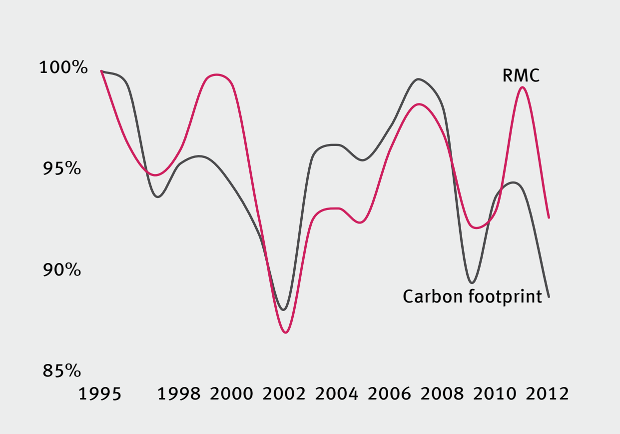


Figure 55 Source: WU, 2017 b

More than half (54 %) of the emissions produced during the manufacture of goods and services consumed in Germany occur in Germany itself. The rest is produced in other countries. 10 % originate in China, while 4 % respectively occur in Russia and the United States. In this context, the energy and agriculture sectors have lower indirect than direct emissions. The manufacturing industry accounts for the largest share in indirect emissions (WU, 2017b).

The production of greenhouse gas emissions is closely linked to the extraction, processing and transport of raw materials as well as to the use of products. The entire product lifecycle requires energy, the use of which results in the creation of greenhouse gases. The direct link between these two categories of resource use at product level can only be assessed by means of a detailed life cycle analysis.

At the level of the national economy, trends can be compared allowing conclusions about interdependencies to be drawn.

When the carbon footprint and material consumption (RMC) are contrasted with one another over time (↖ Fig. 55) it becomes evident that both curves follow a similar path. This may be explained by the fact that increased product consumption also causes higher emissions along the supply chains. At the same time, the economic crisis of 2008 produced a slump both in the RMC indicator and in the CO_2 footprint.

The UBA is currently investigating concrete measures and pathways for the development of a greenhouse gas-neutral and resource-conserving Germany (UBA, 2017 e). Results of initial scenario calculations suggest that greenhouse gas emissions in Germany could be reduced by 95% by 2050 compared to 1990 levels, by means of an energy transition and an end to the use of fossil fuels, together with systematic adjustment measures in the sectors under discussion (↘ Fig. 56). There are increases in raw material consumption associated with creating a renewable energy system and its infrastructure, yet raw material consumption in Germany is set to fall nonetheless by 60 % overall by 2050 compared to 2010. This is due primarily to the elimination of fossil fuels use and to reductions in new land sealing, together with an increase in the circularity of industrial processes. This shows that an ambitious and integrated approach to both climate and resource protection is mutually reinforcing and that both goals can be achieved together. A systemic link between these two themes must be the subject of even greater debate and implementation, if a transformation is to be realised in practice.

Development of raw material consumption (RMC) and the carbon footprint until 2050 in the scenario "GreenEe"

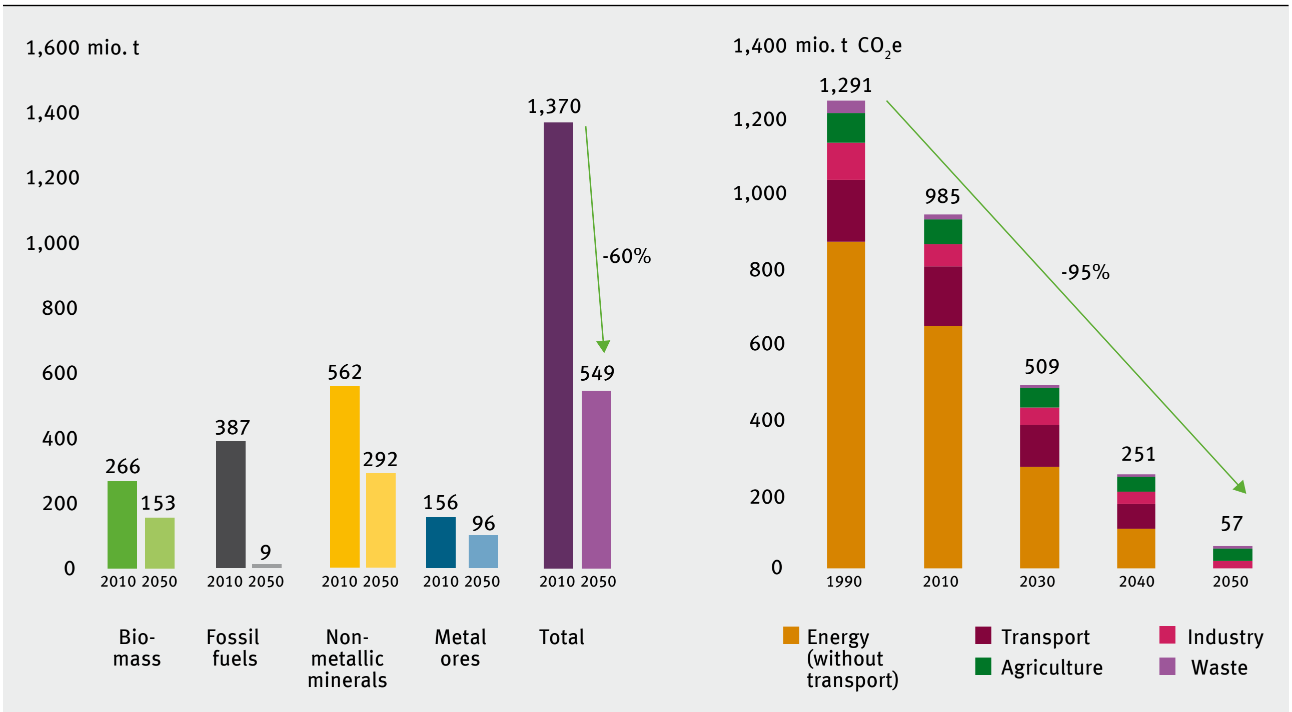


Figure 56 Source: UBA, 2017 e

Glossary

The glossary is mainly based on the glossary of the second German Resource Efficiency Programme (ProgRess II; Deutsche Bundesregierung 2016b) and the glossary on resource conservation of the German Environment Agency (UBA 2012).

Biomass: Category of material flow analysis:
Comprises all organic matter, which accrues or is produced by plants or animals. Where biomass is used to produce energy, a distinction is made between renewable raw materials (energy crops such as rape, maize or cereals) and organic residues and waste materials.

Circular economy: An economic model that minimises resource input and waste generation, emissions and energy waste by closing, slowing and reducing energy and material cycles. An important component is on one hand product design, with a focus on extending the lifespan of goods, reparability, and potentials for reuse and recycling. On the other hand, new business models that aim at achieving common use of goods (sharing) and the purchase of services instead of goods are intended to ensure more efficient production and use.

Decoupling – relative / absolute: The removal or reduction of a quantitative link between interdependent developments. The term is often used in situations in which the use of natural resources increases more slowly than economic growth, which is defined as “relative decoupling”. “Absolute decoupling” refers to situations in which resource use remains the same or even falls as the economy continues to grow.

Direct material input (DMI): Material flow indicator:
The mass flow of materials directly entering a national economy, which are either further processed or consumed within it. Calculation: the sum of the mass of domestically extracted raw materials plus imported raw materials, semi-finished or finished goods (cf. “Direct raw material flows”).

Direct raw material flows: Direct raw material flows comprise the actual weight of extracted raw materials and traded products. For the purposes of analysing raw material flows, the latter are assigned to one of the four major raw material groups (biomass, fossil fuels, metal ores or non-metallic minerals), depending on their primary component, for the purposes of analysing raw material flows.

DMC: Material flow indicator:
see “Domestic material consumption (DMC)”

DMI: Material flow indicator:
see “Direct material input (DMI)”

Domestic material consumption (DMC):
Material flow indicator: Describes the mass of those materials that are consumed within a country or a national economy. Calculation: the sum of domestic extraction plus the mass of directly imported raw materials, semi-finished and finished goods, minus the mass of directly exported raw materials, semi-finished and finished goods.

Efficiency: The relationship between a particular use, product or service and the outlay or raw material input that it requires.

Extraction: Material flow indicator:
The extraction of raw materials from the environment or their displacement within the environment as a result of human activities. Calculated as the total mass of (1) harvested biomass, (2) mined non-metallic minerals and metal ores, and (3) extracted fossil fuels. A distinction is made between used and unused extraction. Extraction is defined as used where the extracted material is exploited economically. Unused extraction refers to extracted raw material that remains in the environment, e.g. deposited overburden from coal mining.
Common synonym: “domestic extraction”

Final use / Final demand: Goods, which are not further processed in the domestic economy. These include goods for consumption, public investments or exports to other countries.

Flow resources: Wind, geothermal, tidal and solar energy. Although these resources cannot be exhausted, their use requires the input of other resources. Examples are the energy, raw materials and space required to construct wind turbines or photovoltaic cells.

Fossil fuels: Category of material flow analysis:
Comprises animal or plant-based energy resources found in deposits, such as coal, crude oil or natural gas, that have accumulated over geological periods and are therefore non-renewable.

Indirect raw material flows: Indirect flows comprise the total mass of all those raw materials that are input along all value chains for traded goods (cf. “Raw material equivalents (RMEs)”). The sum of all direct and indirect flows linked to goods consumed within a country is also termed “footprint” or “rucksack”.

Land footprint: The sum of all land areas used along value chains both in and outside a country for the production of goods and services consumed within that country. It is an indicator of the resource and area use for the products of agriculture and forestry and is sub-divided into three major categories: cropland, grassland and forest land.

Metal ores: Category in material flow analysis: Includes all metallic minerals.

Monetary trade balance: Indicator of the system of national accounts: calculated as the value of exports minus the value of imports. It indicates a monetary trade surplus or deficit of a national economy.

Natural resources: Resources available in the natural environment and used by humans. These include renewable and non-renewable raw materials, physical space (or area), flow resources (e.g. geothermal energy, wind, tidal and solar energy), environmental media (water, soil, air), and ecosystems (VDI 2016).

Net imports: The difference between imports and exports.

Non-metallic minerals: Category in material flow analysis: Comprises industrial minerals such as clay minerals, quartz or kaolin, and construction minerals such as sand, gravel, etc.

Overburden: Rock with no or very little value (waste rock), which has to be excavated to obtain access to the raw materials from a deposit, yet which has no input into the economic system.

Physical trade balance: Material flow indicator: Calculated as the mass of imports minus the mass of exports. It indicates the physical trade balance surplus or physical trade deficit of a national economy.

Raw material equivalents (RME): Material flow indicator: Comprising the mass of all the raw materials used along the entire value chain to produce goods. The indicator does not include unused extraction, such as overburden, tailings from mining activities, and excavated soil, which cannot be exploited economically.

Raw material input (RMI): Material flow indicator: Calculated as the total mass of raw material inputs along value chains for goods or services that are processed or consumed in a country or by a national economy. Calculation: the sum of domestically used extraction and the mass of imports in RME (cf. “Raw material equivalents (RMEs)”).

Raw materials: Substances or mixtures of substances in an unprocessed or unfinished state, which are used as inputs to a production process. A distinction is made between primary and secondary raw materials.

Raw material consumption (RMC): Material flow indicator: Comprising the mass of raw materials input along the value chains for goods and services that are consumed in a country or by a national economy. Calculation: the sum of domestically used extraction and imports in RME, minus exports in RME (cf. “Raw material equivalents (RMEs)”).

Raw material use: An umbrella term for the use of raw materials by society. This includes the use of raw materials for both production and consumption.

Raw material productivity: In ProgRess II this indicator functions alongside total raw material productivity as an indicator for the raw material efficiency of the Germany economy. Calculation: the quotient of the price-adjusted gross domestic product (GDP) and the abiotic direct material input ($DMI_{abiotic}$). The commonly used unit is Euro per tonne.

Rebound effect: This term describes the effect by which cost savings produced as a result of efficiency gains do not lead to a decrease in resource use of equal extent, since these savings cause an increase in demand and consumption.

Recycling: Any recovery operation, through which waste materials are reprocessed into metal products, materials or substances – either for their original purpose or for another use. This includes the processing of organic materials, but excludes energy recovery and reprocessing into materials that are intended for use as fuels or for backfilling operations.

Renewable energies: Forms of energy that are produced from renewable resources as energy carriers. These include, for example, energy from biomass or from flow resources such as hydropower, geothermal energy, wind or solar energy.

RMC: Material flow indicator: see “Raw material consumption (RMC)”

RME: Material flow indicator: see „Raw material equvivalents (RME)“

RMI: Material flow indicator: see “Raw material input (RMI)“

Secondary raw materials: Raw materials that are recovered from waste processing activities (e.g. recycling) or production residues.

Sink: Endpoint for mass flows. In the context of natural resources sinks refer to the absorption capacity (e.g. for pollutants) of the natural environment.

TMC: Material flow indicator:
see “Total material consumption (TMC)”

TMR: Material flow indicator:
see “Total material requirement (TMR)”

Total material consumption (TMC): Material flow indicator: total mass of used and unused materials extracted along the value chains for products and services consumed within a country. Calculation: domestic used and unused extraction plus imports and exports in RME (cf. “Raw material equivalents (RMEs)”) plus the unused material flows associated with the traded goods.

Total raw material productivity: A production-based indicator for the raw material efficiency of the German economy. It forms part of the German Strategy for Sustainable Development and of ProgRess II. Calculation: price-adjusted gross domestic product plus price-adjusted outlay for imports (GDP + IMP) divided by the raw material input (RMI).

Total material requirement (TMR): Material flow indicator: total mass of used and unused materials extracted along the value chains for products and services consumed within a country. Calculation: domestic used and unused extraction plus imports in RME (cf. “Raw material equivalents (RMEs)” plus the unused material flows associated with the traded goods.

Unused extraction: Material flow indicator:
The mass of materials that has to be displaced in order to gain access to materials required for eventual use. Examples include overburden in the mining industry and bycatch in the fisheries sector. Unused extraction is not entering the economic system and therefore has no monetary value.

Water footprint: The total quantity of water used within or outside a country along value chains for all goods and services consumed in a country. It is subdivided into a “blue” (surface water and groundwater) and “green” (rainwater) component.

Water exploitation index (WEI): Shows the level of water abstraction measured against the renewable water resources. This is used to identify whether a country is experiencing water shortage or water stress. The threshold value for water stress is 20 %, while 40 % or above indicates a level of severe water stress.

Data tables

Population: Destatis 2017, Umweltnutzung und Wirtschaft, Tabellen zu den Umweltökonomischen Gesamtrechnungen, Teil 1: Gesamtwirtschaftliche Übersichtstabellen, Wirtschaftliche Bezugszahlen, Table 1.1

Table A 1: Abiotic and biotic extraction in 1.000 tonnes; tonnes per capita

Data sources: Used extraction: Destatis 2017, Umweltnutzung und Wirtschaft, Tabellen zu den Umweltökonomischen Gesamtrechnungen, Teil 4: Rohstoffe, Wassereinsatz, Abwasser, Abfall, Table 5.1
Unused extraction: Destatis 2017, Umweltnutzung und Wirtschaft, Tabellen zu den Umweltökonomischen Gesamtrechnungen, Teil 1: Gesamtwirtschaftliche Übersichtstabellen, Wirtschaftliche Bezugzahlen, Table 1.4

ABIOTIC EXTRACTION	1994	2000	2005	2010	2015	Changes 1994–2015	Per capita 1994	Per capita 2015
USED EXTRACTION								
Fossil fuels	277,980	220,661	220,882	196,064	194,807	-30%	3.4	2.4
Hard coal	52,405	33,591	24,907	12,900	6,223	-88%	0.6	0.1
Lignite	207,086	167,694	177,907	169,403	178,151	-14%	2.6	2.2
Crude oil	2,937	3,119	3,573	2,511	2,413	-18%	0.0	0.0
Natural gas and casinghead gas	15,033	15,742	14,203	10,899	7,552	-50%	0.2	0.1
Other fossil fuels	519	515	292	351	468	-10%	0.0	0.0
Minerals	844,495	751,652	613,405	575,992	574,398	-32%	10.4	7,0
Ores	146	462	362	394	489	236%	0.0	0.0
Construction minerals	780,495	691,853	550,431	511,413	517,285	-34%	9.6	6.3
Industrial minerals	63,854	59,338	62,612	64,185	56,624	-11%	0.8	0.7
TOTAL	**1,122,475**	**972,313**	**834,287**	**772,056**	**769,206**	**-31%**	**13.8**	**9.4**
UNUSED EXTRACTION								
Overburden of minerals and fossil fuels	1,920,412	1,565,038	1,758,199	1,723,254	1,605,003	-16%	23.7	19.6
Overburden	139,868	131,438	115,994	106,738	108,396	-23%	1.7	1.3
Soil, rock and dredged material	105,629	161,349	106,830	108,360	120,978	15%	1.3	1.5
TOTAL	**2,165,909**	**1,857,825**	**1,981,023**	**1,938,352**	**1,834,376**	**-15%**	**26.7**	**22.5**

BIOTIC EXTRACTION	1994	2000	2005	2010	2015	Changes 1994–2015	Per capita 1994	Per capita 2015
USED EXTRACTION								
Biomass from agriculture	194,958	221,450	220,791	223,066	244,155	25%	2.4	3.0
Cereals	36,329	45,271	45,980	44,039	48,867	35%	0.4	0.6
Pules and root crops	36,684	42,685	37,913	34,096	33,590	-8%	0.5	0.4
Commercial crops	3,288	3,765	5,247	5,878	5,174	57%	0,0	0,1
Vegetables and fruits	7,047	9,024	7,625	7,529	8,332	18%	0.1	0,1
Intermediate crops	4,215	2,990	1,855	2,169	2,191	-48%	0.1	0.0
Fodder crops	106,844	117,172	121,617	128,829	145,467	36%	1.3	1.8
Other biomass	551	543	554	526	534	-3%	0.0	0.0
Biomass from forestry	16,802	24,503	26,572	25,955	26,954	60%	0.2	0.3
Hard Wood	12,406	18,487	20,244	18,738	18,677	51%	0.2	0.2
Soft wood and bark	4,396	6,016	6,328	7,217	277	88%	0.1	0.1
Animal biomass	222	249	314	284	319	44%	0.0	0.0
TOTAL	**211,981**	**246,203**	**247,677**	**249,304**	**271,428**	**28%**	**2.6**	**3.3**
UNUSED EXTRACTION								
Unused Biomass	**198,599**	**201,193**	**201,287**	**176,602**	**172,680**	**-13%**	**2.4**	**2.1**

TOTAL DOMESTIC EXTRACTIOn	1994	2000	2005	2010	2015	Changes 1994–2015	Per capita 1994	Per capita 2015
Used	1,334,456	1,218,516	1,081,964	1,021,361	1,040,634	-22%	16.4	12.7
Unused	2,364,508	2,059,018	2,182,310	2,114,954	2,007,056	-15%	29.1	24.6

Table A 2: Extraction in the federal states in 1.000 tonnes, tonnes per capita

Data source: Statistische Ämter der Länder 2017, Umweltökonomische Gesamtrechnungen der Länder. Band 1: Indikatoren und Kennzahlen. Table 2.1.1–2.1.16

		1994	2000	2005	2010	2015	Changes 1994–2015	Per capita 1994	Per capita 2015
Baden-Württemberg	Fossil fuels	384	340	294	352	469	22%	0.04	0.04
	Non-metal. minerals	119,989	118,252	86,385	81,146	81,976	-32%	11.71	7.59
	Biomass	20,456	28,459	20,319	20,639	20,843	2%	2.00	1.93
	TOTAL	**140,829**	**147,051**	**106,998**	**102,137**	**103,288**	**-27%**	**13.74**	**0.01**
Bavaria	Fossil fuels	179	98	90	35	49	-72%	0.02	0.00
	Non-metal. minerals	142,829	127,454	94,592	94,472	101,583	-29%	12.01	7.96
	Biomass	50,003	53,284	55,068	53,889	53,056	6%	4.21	4.16
	TOTAL	**193,012**	**180,835**	**149,750**	**148,396**	**154,688**	**-20%**	**16.23**	**0.01**
Branden-burg	Fossil fuels	47,692	40,329	40,378	37,996	32,514	-32%	18.81	13.16
	Non-met. minerals	27,388	27,568	25,196	25,062	24,099	-12%	10.80	9.75
	Biomass	9,243	11,047	13,001	13,432	15,582	69%	3.65	6.30
	TOTAL	**84,323**	**78,944**	**78,574**	**76,491**	**72,194**	**-14%**	**33.26**	**0.03**
Hessen	Fossil fuels	151	156	0	0	0	-100%	0.03	0.00
	Non-met. minerals	44,744	43,960	33,484	31,829	32,966	-26%	7.49	5.37
	Biomass	9,887	10,744	10,448	11,138	10,970	11%	1.66	1.79
	TOTAL	**54,783**	**54,860**	**43,931**	**42,967**	**43,936**	**-20%**	**9.17**	**0.01**
Mecklen-burg-Vor-pommern	Fossil fuels	27	12	8	5	4	-85%	0.01	0.00
	Non-metal. minerals	22,173	13,802	14,226	12,318	13,342	-40%	12.07	8.31
	Biomass	9,921	13,932	14,222	15,087	18,058	82%	5.40	11.25
	TOTAL	**32,121**	**27,746**	**28,456**	**27,410**	**31,404**	**-2%**	**17.49**	**0.02**
Lower Saxony	Fossil fuels	18,786	20,109	15,617	12,859	9,170	-51%	2.45	1.16
	Non-metal. minerals	61,166	52,980	42,157	38,412	41,265	-33%	7.97	5.24
	Biomass	39,514	45,898	48,465	49,407	60,212	52%	5.15	7.64
	TOTAL	**119,466**	**118,987**	**106,240**	**100,678**	**110,647**	**-7%**	**15.56**	**0.01**
North Rhine-Westphalia	Fossil fuels	145,091	119,496	117,453	102,491	101,602	-30%	8.16	5.72
	Non-metal. minerals	150,591	135,177	362	390	461	216%	8.47	0.03
	Biomass	24,404	26,737	130,645	120,835	113,238	-25%	1.37	6.38
	TOTAL	**320,086**	**281,409**	**27,010**	**25,377**	**27,880**	**14%**	**18.00**	**1.57**
Rheinland-Pfalz	Fossil fuels	121	78	275,470	249,093	243,181	-24%	0.03	0.01
	Non-metal. minerals	49,566	53,640	46	104	204	68%	12.59	0.05
	Biomass	8,867	9,638	43,181	43,092	42,597	-14%	2.25	10.56
	TOTAL	**58,554**	**63,356**	**9,832**	**829**	**9,583**	**8%**	**14.87**	**2.38**
Saarland	Fossil fuels	8,676	6,018	53,060	54,025	52,385	-11%	8.01	0.01
	Non-metal. minerals	5,256	4,062	5,126	1,451	106	-99%	4.85	0.11
	Biomass	649	772	2,433	2,591	2,252	-57%	0.60	2.27
	TOTAL	**14,581**	**10,853**	**729**	**856**	**811**	**25%**	**13.46**	**0.82**
Saxony	Fossil fuels	43,680	23,429	8,287	4,898	3,169	-78%	9.50	0.00
	Non-metal. minerals	87,656	60,199	31,916	31,736	39,927	-9%	19.07	9.81
	Biomass	9,124	10,340	54,975	46,317	43,500	-50%	1.99	10.69
	TOTAL	**140,460**	**93,969**	**11,319**	**10,663**	**11,415**	**25%**	**30.56**	**2.80**
Saxony-Anhalt	Fossil fuels	12,468	9,010	98,210	88,716	94,842	-32%	4.50	0.02
	Non-metal. minerals	60,535	57,677	6,891	7,374	9,255	-26%	21.86	4.13
	Biomass	11,693	13,743	46,862	43,589	42,180	-30%	4.22	18.83
	TOTAL	**84,696**	**80,429**	**14,343**	**15,023**	**15,703**	**34%**	**30.59**	**7.01**
Schleswig-Holstein	Fossil fuels	448	1,345	68,096	65,986	67,138	-21%	0.17	0.03
	Non-metal. minerals	14,309	15,484	3,013	1,623	1,389	210%	5.30	0.49
	Biomass	9,176	11,336	13,411	15,878	18,636	30%	3.40	6.55
	TOTAL	**23,933**	**28,164**	**12,319**	**14,605**	**16,594**	**81%**	**8.86**	**5.83**
Thuringia	Fossil fuels	53	41	28,743	32,105	36,619	53%	0.02	0.01
	Non-metal. minerals	40,980	36,145	26	21	16	-71%	16.23	0.01
	Biomass	8,165	8,698	28,984	26,254	22,478	-45%	3.23	10.39
	TOTAL	**49,198**	**44,884**	**9,414**	**9,134**	**9,337**	**14%**	**19.49**	**4.32**

Table A 3: Direct trade in 1.000 tonnes

Data source: Destatis 2017, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Rohstoffe, Wassereinsatz, Abwasser, Abfall, Umweltschutzmaßnahmen. Tables 5.2 and 5.3

	1994	2000	2005	2010	2015	Changes 1994–2015
IMPORTS						
TOTAL	**463,150**	**520,990**	**561,811**	**589,872**	**641,560**	**39%**
Raw materials	277,263	305,517	326,420	322,811	354,770	28%
Fossil fuels	172,460	194,532	227,715	214,058	244,059	42%
Metal ores	47,030	51,851	47,025	47,850	47,381	1%
Non-metallic minerals	35,689	34,110	25,516	25,588	22,143	-38%
Biomass	22,084	25,023	26,164	35,316	41,187	87%
Semi-finished products from …	105,624	112,250	113,669	127,073	134,664	27%
… fossil fuels	48,514	53,506	52,281	57,240	59,877	23%
… metal ores	9,583	13,001	17,217	17,958	17,640	84%
… non-metallic minerals	27,875	23,005	16,847	18,665	19,005	-32%
… biomass	19,653	22,737	27,324	33,211	38,141	94%
Finished products, mainly from…	80,263	103,224	121,722	139,987	152,127	90%
… fossil fuels	15,532	20,263	25,198	29,299	33,625	116%
… metal ores	30,562	42,142	48,375	57,214	62,117	103%
… non-metallic minerals	5,247	7,525	8,733	10,915	11,599	121%
… biomass	28,922	33,293	39,416	42,559	44,786	55%
EXPORTS						
TOTAL	**223,181**	**289,245**	**357,022**	**365,296**	**398,125**	**78%**
Raw materials	55,297	74,396	78,087	80,496	90,135	63%
Fossil fuels	4,967	13,424	15,120	14,996	29,638	497%
Metal ores	171	215	147	192	292	70%
Non-metallic mlnerals	34,708	37,881	41,340	44,306	36,400	5%
Biomass	15,450	22,876	21,480	21,002	23,806	54%
Semi-finished products from …	86,064	98,623	130,108	120,392	130,857	52%
… fossil fuels	23,814	26,945	37,626	27,723	40,554	70%
… metal ores	14,982	14,737	15,227	18,939	17,572	17%
… non-metallic minerals	28,607	31,370	46,569	36,837	34,441	20%
… biomass	18,662	25,570	30,685	36,893	38,291	105%
Finished products, mainly from…	81,819	116,226	148,827	164,408	177,133	116%
… fossil fuels	20,648	26,753	34,736	37,974	40,663	97%
… metal ores	36,763	52,537	64,092	68,608	76,316	108%
… non-metallic minerals	5,525	9,188	11,673	13,856	14,507	163%
… biomass	18,883	27,749	38,326	43,970	45,647	142%

Table A 4: Direct and indirect trade (RME) in mio. tonnes

Data source: Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Lange Reihen 2000–2014, Tables I1, I2, L1, L2

	Based on national accounts revision 2011				Based on national accounts revision 2014				
	2000	2008	2009	2010	2010	2011	2012	2013	2014
IMPORTS									
TOTAL	**1,443**	**1,677**	**1,412**	**1,712**	**1,601**	**1,678**	**1,569**	**1,606**	**1,540**
Fossil fuels	454	580	495	556	520	530	508	518	499
Metal ores	740	780	616	826	804	845	763	792	723
Non-metallic minerals	138	144	129	148	139	159	142	140	136
Biomass	111	174	172	181	138	143	156	157	182
EXPORTS									
TOTAL	**1,132**	**1,430**	**1,232**	**1,479**	**1,330**	**1,414**	**1,395**	**1,390**	**1,339**
Fossil fuels	271	367	304	345	333	343	346	331	322
Metal ores	598	705	593	782	684	732	709	727	654
Non-metallic minerals	140	180	160	175	155	168	157	155	149
Biomass	123	178	175	178	158	170	182	177	214

2000 = 100	2000	2008	2009	2010	2011	2012	2013	2014
IMPORTS								
TOTAL	**100**	**116**	**98**	**119**	**124**	**116**	**119**	**114**
Metal ores	100	105	83	112	117	106	110	100
Fossil fuels	100	128	109	122	125		122	117
Non-metallic minerals	100	104	93	107	123	110	108	105
Biomass	100	157	155	163	170	184	186	215
EXPORTS								
TOTAL	**100**	**126**	**109**	**131**	**139**	**137**	**137**	**132**
Metal ores	100	118	99	131	140	136	139	125
Fossil fuels	100	135	112	127	131	132	126	123
Non-metallic minerals	100	129	114	125	136	127	125	120
Biomass	100	145	142	145	156	167	163	197

Table A 5: Decoupling in mio. tonnes, mio. Euro

Data sources: Destatis 2017, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 1: Gesamtwirtschaftliche Übersichtstabellen, wirtschaftliche Bezugszahlen, Table 1.2
Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Long time series 2000–2014, Table I 11

DMI: Direct material input
DMI_{abiot}: Abiotic direct material input
DMC: Domestic material consumption
RMI: Raw material input
RMC: Raw material consumption

DMI	1994	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL	1,798	1,740	1,644	1,695	1,584	1,611	1,727	1,670	1,662	1,723	1,682

DMI_{abiot}	1994	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015
TOTAL	1,515	1,412	1,303	1,326	1,212	1,251	1,332	1,274	1,284	1,298	1,287

RMI	Based on national accounts revision 2011				Based on national accounts revision 2014				
	2000	2008	2009	2010	2010	2011	2012	2013	2014
TOTAL	2,642	2,748	2,444	2,716	2,622	2,792	2,653	2,665	2,643

RMC	Based on national accounts revision 2011				Based on national accounts revision 2014				
	2000	2008	2009	2010	2010	2011	2012	2013	2014
TOTAL	1,509	1,318	1,212	1,236	1,292	1,377	1,258	1,274	1,303

TREND	1994	2000	2005	2008	2010	2012	2013	2014	2015
GDP/DMI_{abiot}	100	120	134	148	148	152	151	152	156

GDP/DMI: Raw material productivity
GDP: Gross domestic product

TREND	2000	2005	2010	2011	2012	2013	2014
(GDP+IMP)/RMI	100	107	117	115	121	122	126

(GDP+IMP)/RMI: Total raw material productivity
GDP+IMP: Gross domestic product plus imports

Table A 6: Consumption indicators in mio. tonnes, tonnes per capita

Data sources: DMC: Destatis 2017, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Rohstoffe, Wassereinsatz, Abwasser, Abfall, Umweltschutzmaßnahmen, Tables 5.1–5.3
RMC: Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Long time series 2000–2014. Table L5

DMC	1994	2000	2008	2009	2010	2011	2012	2013	2014	2015	Per cap. 1994	Per cap. 2000	Per cap. 2014	Per cap. 2015	Total 1994 – 2015	Chg 2000 – 2014
TOTAL	**1,574**	**1,450**	**1,307**	**1,245**	**1,246**	**1,348**	**1,302**	**1,292**	**1,343**	**1,284**	**19.4**	**17.8**	**16.6**	**15.7**	**-18%**	**-7%**
Metal ores	35	40	37	21	36	35	29	31	34	33	0.4	0.5	0.4	0.4	-6%	-15%
Non-metallic minerals	844	737	567	537	536	594	560	560	569	541	10.4	9.1	7.0	6.6	-36%	-23%
Fossil fuels	465	422	435	413	416	424	417	425	418	422	5.7	5.2	5.2	5.2	-9%	-1%
Biomass	230	251	268	275	259	295	296	276	322	288	2.8	3.1	4.0	3.5	25%	28%

RMC	Based on national accounts revision 2011				Based on national accounts revision 2014					Change 2000 – 2014	Per capita 2000	Per capita 2014
	2000	2008	2009	2010	2010	2011	2012	2013	2014			
TOTAL	**1,509**	**1,318**	**1,212**	**1,236**	**1,292**	**1,377**	**1,258**	**1,274**	**1,303**	**83**	**18.5**	**16.1**
Metal ores	142	75	23	44	120	113	54	65	69	18	1.7	0.9
Fossil fuels	407	425	394	410	386	391	373	392	377	98	5.0	4.7
Non-metallic minerals	726	559	530	529	557	619	576	578	586	77	8.9	7.2
Biomass	234	259	265	253	229	253	255	240	272	128	2.9	3.4

Table A 7: Raw material consumption (RMC) of final demand by raw material categories, in mio. tonnes

Data sources: Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Reihen 2000–2010. Table A1-2000
Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Reihen 2010–2014. Table A1-2014
Destatis 2018, Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Long time series 2000–2014. Table I

2010	Total	Consumption	Equipment and other infra-structure	Buildings	Changes in stock
TOTAL	**1,509**	**806**	**139**	**747**	**-184**
Metal ores	69	111	70	45	-157
Non-metallic minerals	726	139	15	642	-70
Fossil fuels	407	335	34	39	-2
Biomass	234	226	4	13	-9

2014	Total	Consumption	Equipment and other infra-structure	Buildings	Changes in stock
TOTAL	**1,303**	**797**	**107**	**629**	**-229**
Metal ores	69	111	70	45	-157
Non-metallic minerals	586	95	10	548	-66
Fossil fuels	377	322	23	31	1
Biomass	272	270	4	6	-8

RMC 2000=100	2000	2008	2009	2010	2011	2012	2013	2014
TOTAL	**100**	**87**	**80**	**82**	**87**	**80**	**81**	**83**
Metal ores	100	53	16	31	29	14	17	18
Non-metallic minerals	100	77	73	73	81	75	76	77
Fossil fuels	100	104	97	101	102	97	102	98
Biomass	100	111	113	108	119	120	113	128

References

BfG, 2016: *Mitteilung vom 09.12.2016*. Koblenz: Bundesanstalt für Gewässerkunde.

BMEL, 2017: *Ökologischer Landbau in Deutschland*. Bundesministerium für Ernährung und Landwirtschaft. http://www.bmel.de/DE/Landwirtschaft/Nachhaltige-Landnutzung/Oekolandbau/_Texte/OekologischerLandbauDeutschland.html. Abgerufen am 11.9. 2017.

BMUB, 2016: *Klimaschutzplan 2050. Klimaschutzpolitische Grundsätze und Ziele der Bundesregierung*. Berlin: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit.

BMWI, 2014: *Erneuerbare-Energien-Gesetz – EEG 2014*. Berlin: Bundesministerium für Wirtschaft und Energie.

BMWI, 2017: *Energiedaten: Gesamtausgabe*. Stand Mai 2017. Berlin: Bundesministerium für Wirtschaft und Energie.

BMWI, 2018: *Energiedaten: Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland*. Stand März 2018. Berlin: Bundesministerium für Wirtschaft und Energie.

Bruckner, M., G. S., G. Fischer, S. Tramberend, S. Wunder, and T. Kaphengst, 2017: *Development of consumption-based land use indicators – Synthesis Report*. Dessau: German Federal Environment Agency.

Destatis, 2015 a: *Land-und Forstwirtschaft, Fischerei. Viehbestand*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2015 b: *Land- und Forstwirtschaft, Fischerei. Bodenfläche nach Art der tatsächlichen Nutzung. 2014*. Ausgabe 2015. Wiesbaden: Statistisches Bundesamt.

Destatis, 2016 a: *Produzierendes Gewerbe. Düngemittelversorgung. Wirtschaftsjahr 2015/2016*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2016 b: *Nachhaltige Entwicklung in Deutschland. Indikatorenbericht 2016*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2016 c: *Fachserie 19*, R. 2.1.1 und 2.2, verschiedene Jahrgänge; übernommen aus Daten zur Umwelt 2017, Wiesbaden: Statistisches Bundesamt.

Destatis, 2016 d: *Land- und Forstwirtschaft, Fischerei. Bodenfläche nach Art der tatsächlichen Nutzung. 2015*. Ausgabe 2016. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 a: *Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen*. Teil 4: Rohstoffe, Wassereinsatz, Abwasser, Abfall, Umweltschutzmaßnahmen. Ausgabe 2017. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 b: *Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen*. Teil 1: Gesamtwirtschaftliche Übersichtstabellen, wirtschaftliche Bezugszahlen. Ausgabe 2016. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 c: *GENESIS Datenbank*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 d: *Außenhandel. Rangfolge der Handelspartner im Außenhandel der Bundesrepublik Deutschland*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 e: *Abfallbilanz (Abfallaufkommen/-verbleib, Abfallintensität, Abfallaufkommen nach Wirtschaftszweigen). 2015*. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 f: *Private Konsumausgaben (Lebenshaltungskosten) – Deutschland*. https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/EinkommenKonsumLebensbedingungen/Konsumausgaben/Tabellen/PrivateKonsumausgaben_D.html. Abgerufen am 02.11.2011. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 g: *Gesundheitsausgaben im Jahr 2015 um 4,5 % gestiegen*. https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2017/02/PD17_061_23611.html;jsessionid=C0A78C5B94C5BB309D99C2527BB07228.cae1. Abgerufen am 14.09.2017. Wiesbaden: Statistisches Bundesamt.

Destatis, 2017 h: *Direkte und indirekte CO_2-Emissionen in Deutschland 2005–2013*. Ausgabe 2017. Wiesbaden: Statistisches Bundesamt.

Destatis, 2018: *Umweltökonomische Gesamtrechnungen. Aufkommen und Verwendung in Rohstoffäquivalenten. Lange Reihen 2000 bis 2014*. Wiesbaden: Statistisches Bundesamt.

Deutsche Bundesregierung, 2007: *Gesetz zur Finanzierung der Beendigung des subventionierten Steinkohlenbergbaus zum Jahr 2018 (Steinkohlefinanzierungsgesetz)*. Steinkohlefinanzierungsgesetz vom 20. Dezember 2007 (BGBl. I S. 3086), das zuletzt durch Artikel 306 der Verordnung vom 31. August 2015 (BGBl. I S. 1474) geändert worden ist. Berlin: Bundesministerium der Justiz und für Verbraucherschutz.

Deutsche Bundesregierung, 2012: *Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz – KrWG)*. Berlin: Deutsche Bundesregierung.

Deutsche Bundesregierung, 2013: *Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder*. Berlin: Deutsche Bundesregierung.

Deutsche Bundesregierung, 2016 a: *Deutsche Nachhaltigkeitsstrategie*. Neuauflage. Berlin: Deutsche Bundesregierung.

Deutsche Bundesregierung, 2016 b: *Deutsches Ressourceneffizienzprogramm (ProgRess) II: Fortschrittsbericht 2012–2015 und Fortschreibung 2016–2019. Programm zur nachhaltigen Nutzung und zum Schutz der natürlichen Ressourcen*. Berlin: Deutsche Bundesregierung.

Deutsche Bundesregierung, 2017a: *Verordnung zur Neuordnung der Klärschlammverwertung*. Drucksache 18/12495. Berlin: Deutsche Bundesregierung.

Deutsche Bundesregierung. 2017b. *Erstes Gesetz zur Änderung des Düngegesetzes und anderer Vorschriften*. Bonn: Deutsche Bundesregierung.

European Commission, 2014: *A policy framework for climate and energy in the period from 2020 to 2030*. COM(2011) 637. Brussels.

European Commission, 2015: *Closing the loop – An EU action plan for the Circular Econom*. COM(2015) 614. Brussels: DG Environment.

EUROSTAT, 2017: *Eurostat database. Version 2017*. Luxembourg: Statistical Office of the European Communities.

EUROSTAT, 2018: *Eurostat database. Version 2018*. Luxembourg: Statistical Office of the European Communities.

FAOSTAT, 2017: *FAO Statistical Databases: Agriculture, Fisheries, Forestry, Nutritio*n. Available at http://faostat.fao.org/. Rome: Statistics Division, Food and Agriculture Organization of the United Nations.

Hoekstra, A. Y., A. K. Chapagain, M. Aldaya, and M. Mekonnen, 2009: *Water Footprint Manual. State of the Art 2009*. Enschede: Water Footprint Network.

ifeu, 2016. *Lebensmittel-CO_2-Rechner*. https://www.klimatarier.com/de/CO2_Rechner. Abgerufen am 09.07.2017.

Kauppinen, T., M. Lettenmeier, and S. Lähteenoja, 2008: *Data envelopment analysis as a tool for sustainable foodstuff consumption. Sustainable consumption and production: framework for action 181*.

Kreislaufwirtschaft Bau, 2017: *Mineralische Bauabfälle Monitoring 2014. Bericht zum Aufkommen und zum Verbleib mineralischer Bauabfälle im Jahr 2014*. Bundesverband Baustoffe – Steine und Erden e.V.

Lange, J., 2009: *Phosphorus – as important as air, as scarce as oil? Working paper as a basis for a workshop*. Freiburg: GTZ Ecosan Programme.

Lutter, S., S. Giljum, and M. Bruckner, 2016 a: *A review and comparative assessment of existing approaches to calculate material footprints*. Ecological Economics 127: 1–10.

Lutter, S., S. Pfister, S. Giljum, H. Wieland, and C. Mutel, 2016 b: *Spatially explicit assessment of water embodied in European trade: A product-level multi-regional input-output analysis*. Global Environmental Change 38: 171–182.

Mekonnen, M. M. and A. Y. Hoekstra, 2011: *The green, blue and grey water footprint of crops and derived crop products*. Hydrol. Earth System Science 15(5): 1577–1600.

Santarius, T., 2014: *Der Rebound-Effekt: ein blinder Fleck der sozial-ökologischen Gesellschaftstransformation*. Rebound Effects: Blind Spots in the Socio-Ecological Transition of Industrial Societies. GAIA-Ecological Perspectives for Science and Society 23(2): 109–117.

Schweizer Nährwertdatenbank, 2017: *Nährwertdaten*. Abgerufen am 22.11.2017.

Stadler, K., R. Wood, T. Bulavskaya, C.-J. Södersten, M. Simas, S. Schmidt, A. Usubiaga, J. Acosta-Fernández, J. Kuenen, M. Bruckner, S. Giljum, S. Lutter, S. Merciai, J. H. Schmidt, M. C. Theurl, C. Plutzar, T. Kastner, N. Eisenmenger, K.-H. Erb, A. de Koning, and A. Tukker, 2018: *EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables*. Journal of Industrial Ecology. DOI: 10.1111/jiec.12303.

Statistik der Kohlenwirtscchaft e. V., 2017: *Braunkohle*. Bergheim: Statistik der Kohlenwirtscchaft e. V.

Statistische Ämter der Länder, 2017: *Umweltökonomische Gesamtrechnungen der Länder. Band 1: Indikatoren und Kennzahlen. Tabellen*. Ausgabe 2017. Arbeitskreis Umweltökonomische Gesamtrechnungen der Länder (AK UGRdL).

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, C. A. de Wit, C. Folke, D. Gerten, J. Heinke, G. M. Mace, L. M. Persson, V. Ramanathan, B. Reyers, and S. Sörlin, 2015: *Planetary boundaries: Guiding human development on a changing planet*. Science 347(6223): 1259855.

UBA, 2010: *Energieziel 2050: 100% Strom aus erneuerbaren Quellen*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2012: *Glossar zum Ressourcenschutz*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2013: *Globale Landflächen und Biomasse nachhaltig und ressourcenschonend nutzen*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2014: *Treibhausgasneutrales Deutschland im Jahr 2050*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2015 a: *Daten und Fakten zu Braun- und Steinkohlen. Status quo und Perspektiven*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2015 b: *Schwerpunkte 2015*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2015 c: *Handel mit Flächenzertifikaten*. Dessau-Roßlau: Umweltbundesamt. https://www.umweltbundesamt.de/daten/luftbelastung/luftschadstoff-emissionen-in-deutschland. Abgerufen am 08.10.2015.

UBA Ressourcenbericht 2016: *Die Nutzung natürlicher Ressourcen. Bericht für Deutschland 2016*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 a: *Kohleverstromung und Klimaschutz bis 2030. Diskussionsbeitrag des Umweltbundesamts zur Erreichung der Klimaziele in Deutschland*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 b: *Erörterung ökologischer Grenzen der Primärrohstoffgewinnung und Entwicklung einer Methode zur Bewertung der ökologischen Rohstoffverfügbarkeit zur Weiterentwicklung des Kritikalitätskonzeptes (ÖkoRess I). Konzeptband. UBA Texte 87/2017*. http://www.umweltbundesamt.de/publikationen/. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 c: *Wasserwirtschaft in Deutschland. Grundlagen, Belastungen, Maßnahmen*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 d: *Daten zur Umwelt 2017*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 e: *Den Weg zu einem treibhausgasneutralen Deutschland ressourcenschonend gestalten*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2017 f: *Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen*. Dessau-Roßlau: Umweltbundesamt.

UBA, 2018: *Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen*. Fassung zur EU-Submission 15.01.2018. Dessau-Roßlau: Umweltbundesamt.

UBA und BMU, 2018: *Pressemitteilung: Klimabilanz 2017: Emissionen gehen leicht zurück. Niedrigere Emissionen im Energiebereich, höhere im Verkehrssektor*. Dessau-Roßlau, Berlin, Umweltbundesamt.

UN IRP, 2017: *Global Material Flows Database*. Version 2017. Paris: International Resource Panel.

UNEP, 2017: *Resource efficiency: Potential and economic implications*. A Report of the International Resource Panel.

United Nations, 2017: *UN Comtrade Database*. UN Trade Statistics Branch, Statistics Division.

USGS, 2015 a: *Mineral Commoditiy Summaries 2015*. Virginia.

USGS, 2015 b: *2015 Minerals Yearbook: Phosphate rock*. US Geological Survey.

USGS, 2016: *Mineral Commoditiy Summaries 2016. Phosphate Rock*. Virginia.

VDI, 2016: *VDI-Richtlinie 4800, Blatt 1. Ressourceneffizienz: Methodische Grundlagen, Prinzipien und Strategien*. Berlin: Beuth., herausgegeben von V. D. I. (VDI). Düsseldorf.

Wiesen, K., J. Teubler, M. Saurat, P. Suski, S. Samadi, S. Kiefer, and O. Soukup, 2017: *Analyse des Rohstoffaufwandes der Energieinfrastruktur in Deutschland*. Sachverständigengutachten des Wuppertal Instituts für Klima, Umwelt, Energie. Im Auftrag des Umweltbundesamts.

Wind Europe, 2018: *Wind in power 2017. Annual combined onshore and offshore wind energy statistics*. Brussles: Wind Europe.

World Nuclear Association, 2015: *Uranium from Phosphates*. http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-from-phosphates.aspx. Abgerufen am 02.08.2017.

WU, 2017 a: Berechnungen basierend auf Exiobase 3.3 im Rahmen des UBA Projektes „*Wissenschaftliche Konzeption und Ausarbeitung eines Berichts „Ressourcennutzung in Deutschland“ (Forschungskennzahl 3714 93 105 0)*“. Wirtschaftsuniversität Wien.

WU, 2017 b: *Der Carbon Footprint von Österreich*. Berechnungen basierend auf EXIOBASE Version 3.3. Detaillierte Ergebnisse verfügbar auf https://www.wu.ac.at/en/ecolecon/research/sustainable-resource-use/ccca. Wirtschaftsuniversität Wien.

List of figures and tables

Figures:

Page 14:
Figure 1: Used raw material extraction in Germany, 2015 | Source: Destatis, 2017 a
Figure 2: Used extraction of non-renewable raw materials in Germany, 2015 | Source: Destatis, 2017 a
Page 15:
Figure 3: Development of used extraction of non-renewable raw materials in Germany, 1994–2015 | Source: Destatis, 2017 a
Figure 4: Trends of the extraction of individual sub-categories of fossil energy sources (left) and mineral raw materials (right) in Germany, 1994–2015 | Source: Destatis, 2017 a
Page 16:
Figure 5: Used extraction of renewable raw materials in Germany, 2013 and 2015 | Source: Destatis, 2017 a
Page 17:
Figure 6: Trend of extraction of renewable raw materials in Germany, 1994–2015 | Source: Destatis, 2017 a
Figure 7: Trends of extraction of individual sub-categories of renewable raw materials in Germany, 1994–2015 | Source: Destatis, 2017 a
Page 19:
Figure 8: Used raw material extraction in the German federal states, 2015 | Source: Statistische Ämter der Länder, 2017
Pages 18/19:
Figure 9: Development of used raw material extraction and shares of the three major categories in the German federal states, 1994 and 2015 | Source: Statistische Ämter der Länder, 2017
Page 20:
Figure 10: Share of lignite in total used raw material extraction in Germany, 2015 | Source: Destatis, 2017 a
Figure 11: Trends of lignite mining in Germany, 1994–2015 | Source: Destatis, 2017 a
Page 21:
Figure 12: Selected data on the use of lignite in Germany, 2015
Sources: Destatis, 2017 a; UBA, 2015 a; Statistik der Kohlenwirtschaft e. V., 2017
Page 24:
Figure 13: Germany's direct trade flows in physical and monetary terms in 2013 and 2015 | Source: Destatis, 2017 c
Page 25:
Figure 14: Development of direct imports and exports in Germany – monetary and physical, by main category, 1994–2015
Sources: Destatis, 2017 a, 2017 c
Figure 15: Comparison between physical and monetary trade balances of Germany with those of other countries, and the development of their trade volumes, 2015 | Sources: Destatis, 2017 c, 2017 d
Page 26:
Figure 16: Comparison of actual weight versus raw material equivalents for Germany's imports and exports, 2014 | Source: Destatis, 2018
Page 27:
Figure 17: Development of Germany's direct and indirect raw material imports and exports, 2000–2014 | Sources: Destatis 2017 a, 2018
Figure 18: Direct and indirect raw material flows through the German economy, by category of raw material, 2014 | Source: WU, 2017 a
Page 28:
Figure 19: Share of imports in raw material inputs (RMI) in Germany by raw material group, 2014 | Source: Destatis 2018
Figure 20: Domestic and foreign share of raw material inputs (RMI) for Germany, by primary raw materials, 2014 | Source: Destatis 2018
Page 29:
Figure 21: Geographical origin of Germany's raw material consumption (RMC) by raw material group and world region, 1995–2014
Source: WU, 2017 a
Pages 30:
Figure 22: Development of phosphorus use and costs in Germany, 1999–2015 | Source: Destatis, 2016 a
Page 31:
Figure 23: World-wide phosphorus reserves, extraction and consumption, 2014 | Sources: FAOSTAT, 2017; USGS, 2015 b und 2016
Page 34:
Figure 24: Raw material inputs (RMI) in Germany by material group, 2000–2014 | Source: Destatis, 2018
Page 35:
Figure 25: Raw material input (RMI) of goods for final demand produced in Germany, 2014 | Source: WU, 2017 a
Figure 26: Comparison of supply chain structures of selected aggregated sectors, 2014 | Source: WU, 2017 a
Page 36:
Figure 27: Development of raw material productivity, 1994-2015, (left) and total raw material productivity (right) in Germany, 2000–2014
Sources: Destatis, 2017 b, 2018
Page 37:
Figure 28: International comparison of decoupling trends, 1995–2014 | Source: WU, 2017 a
Page 38:
Figure 29: Types of waste generation in Germany, 2015 | Source: Destatis 2017 e
Page 39:
Figure 30: Trend of shares of thermal and material waste recovery and disposal in Germany, 2006-2015, by waste type, 2015
Source: Destatis 2017 e
Page 42:
Figure 31: Domestic material consumption (DMC) and Raw material consumption (RMC) in Germany, in absolute values by material group, 2014, and per capita, 2011–2014 | Sources: Destatis, 2017 a, 2018

Page 43:
Figure 32: Development of raw material consumption (RMC) in Germany by raw material group, 2000–2014 | Source: Destatis, 2018
Figure 33: Shares of economic sectors in the raw material consumption of final demand in Germany, by raw material group, 2014
Source: WU, 2017 a
Page 44:
Figure 34: Trend of raw material consumption of final demand in Germany by category, 2010–2014 | Sources: WU, 2017 a; Destatis, 2018
Page 45:
Figure 35: Private and public raw material consumption in Germany by consumption area, 2014 | Source: WU, 2017 a
Figure 36: International comparison of raw material consumption of final demand by share of individual categories, 2014
Source: WU, 2017 a
Page 46:
Figure 37: Monthly raw material consumption and spending per private household in Germany, by area of need and product group, 2014
Sources: Destatis, 2017 f; WU, 2017 a
Page 47:
Figure 38: Trends of raw material consumption linked to foodstuffs consumed in German households by product group, 1995–2014
Source: WU, 2017 a
Figure 39: Comparison between different food products according to nutritional value and resource input to supply the calories required for a daily intake of 2,500 kilocalories | Sources: Kauppinen et al., 2008; Mekonnen and Hoekstra, 2011; ifeu, 2016; Schweizer Nährwertdatenbank, 2017
Page 48:
Figure 40: Trends of raw material consumption of the health sector in Germany by categories of consumption, 1995–2014
Source: WU, 2017 a
Page 49:
Figure 41: Share of upstream services of the health sector and social care services in Germany in the sector's total raw material consumption
Source: WU, 2017 a
Figure 42: Origin of raw materials base for the German healthcare system, 2014 | Source: WU, 2017 a
Page 52:
Figure 43: Water extraction by economic sector in Germany, and share in renewable water resources, 1991–2013 | Source: Destatis, 2016 c
Page 53:
Figure 44: Water flows from nature into the economy in Germany, 2013 | Source: Destatis, 2017 a
Figure 45: Germany's net imports of blue and green water, 2011 | Source: WU, 2017 a
Page 54:
Figure 46: Land use in Germany by type of usage, 1992–2015 | Source: Destatis, 2015 b
Page 55:
Figure 47: Shares of land use for different purposes by federal state, 2015 | Source: Destatis, 2016 d
Figure 48: Organic farms and area utilized by organic farming in Germany, 1996–2015 | Source: BMEL, 2017
Page 56:
Figure 49: Domestic and foreign share of Germany's land footprint by category, 2010 | Source: Bruckner et al., 2017
Page 57:
Figure 50: Germany's cropland land footprint, 1995–2010 | Source: Bruckner et al., 2017
Figure 51:Geographical origin of Germany's forest land footprint, 2010 | Source: Bruckner et al., 2017
Page 58:
Figure 52: Contribution of renewable energies to primary energy consumption and share in gross electricity production, gross final energy consumption and primary energy consumption, 1990–2015 | Source: BMWI, 2017, 2018
Page 59:
Figure 53: Raw material input (RMI) and unused extraction (material) for selected electricity generation options in grammes per kilowatthour of electricity produced | Source: Wiesen et al., 2017
Page 60:
Figure 54: Changes in direct climate emissions and Germany's carbon footprint, 1990–2015
Sources: Destatis, 2017 h; UBA, 2018; UBA and BMU, 2018
Page 61:
Figure 55: Development of raw material consumption (RMC) and the carbon footprint in Germany, 1995–2012 | Source: WU, 2017 b
Figure 56: Development of raw material consumption (RMC) and the carbon footprint until 2050 in the scenario "GreenEe" | Source: UBA, 2017 e

Table:

Page 58:
Table 1: Primary energy generation from renewable energies in Europe, 2015 | Source: EUROSTAT, 2017

Tables Annex:

Page 65:
Tabelle A1: Abiotic and biotic extraction in 1,000 tonnes; tonnes per capita
Page 66:
Tabelle A2: Extraction in the federal states in 1,000 tonnes, tonnes per capita
Page 67:
Tabelle A3: Direct trade in 1,000 tonnes
Page 68:
Tabelle A4: Direct and indirect trade (RME) in mio. tonnes and as change
Page 69:
Tabelle A5: Decoupling in 1,000 tonnes, mio. Euro
Page 70:
Tabelle A6: Consumption indicators in mio. tonnes, tonnes per capita
Page 71:
Tabelle A7: Raw material consumption of final demand by raw material categories

Data sources intro pages

Domestic raw material extraction (pages 12/13):
Destatis, 2017 a, 2017 b | Statistische Ämter der Länder, 2017
Germany's share in global raw material trade (pages 22/23):
Destatis, 2017 a, 2018 | WU, 2017 a
The role of the economy (pages 32/33):
Destatis, 2017 a, 2017 c, 2018 | Deutsche Bundesregierung, 2016
Raw materials for consumption (pages 40/41):
Destatis, 2018 | WU, 2017 a
Other natural resources (pages 50/51):
Destatis, 2017 a | WU, 2017 a | BMWI, 2017, 2018 | Destatis, 2016 | Bruckner et al., 2017 | Wiesen et al., 2017

▸ This publication as download
www.umweltbundesamt.de/en/resourcesreport2018

www.facebook.com/umweltbundesamt.de
www.twitter.com/umweltbundesamt
www.youtube.com/user/umweltbundesamt
www.instagram.com/umweltbundesamt/