

ENVIRONMENTAL- ECONOMIC ACCOUNTING

**Direct and indirect CO₂ emissions in Germany,
2005 – 2013**



2017

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Abbreviations

IPPC	=	Intergovernmental Panel on Climate Change
UNFCCC	=	United Nations Framework Convention on Climate Change
EEA	=	Environmental-Economic Accounting
EUR	=	Euro
LULUCF	=	Land use, land use change, forestry
bn	=	billion
mn	=	million
%	=	percentage
%-points	=	percentage points
fob	=	free on board
cif	=	cost, insurance, freight

Explanation of symbols

X	=	Cell blocked for logical reasons
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Due to rounding, adding individual data may lead to slight discrepancies in totals.

Introduction

Carbon dioxide (CO₂) emissions can be outlined both in terms of origin and of consumption. As part of international reporting of greenhouse gases CO₂ emissions are reported – in terms of origin – for a certain territory based on emission sources¹. When they are considered from a consumer's point of view the emissions are determined in connection with the consumption of goods and are assigned to the various consumption categories. A distinction is drawn between consumption of private households, public consumption, gross fixed capital formation and exports. In doing so a fundamental distinction is made between domestic consumption and exports. The domestic consumption of goods causes emissions domestically and abroad. These emissions can be assigned to domestic consumers. The exports likewise cause emissions in Germany and abroad and are assigned to the rest of the world².

The calculations are based on an extended hybrid input-output model with a regionalisation of the import flows³.

1 Greenhouse inventories as part of Kyoto Reporting in accordance with the UN Climate Convention (UNFCCC).

2 See also: Mayer, H.: "Umweltökonomische Aspekte der Globalisierung" in: *Wirtschaft und Statistik*, No. 12/2007, p. 1261 – 1269.

3 A comprehensive description of the extended Input-Output model is available at DESTATIS: www.destatis.de/ExtendedInputOutputModel.pdf
A short overview on the methods used is included in the paper "CO₂ content of German import and export goods 2000 – 2010" (Wiesbaden, February 2014) available in the Internet: www.destatis.de/ImExResultsPDF

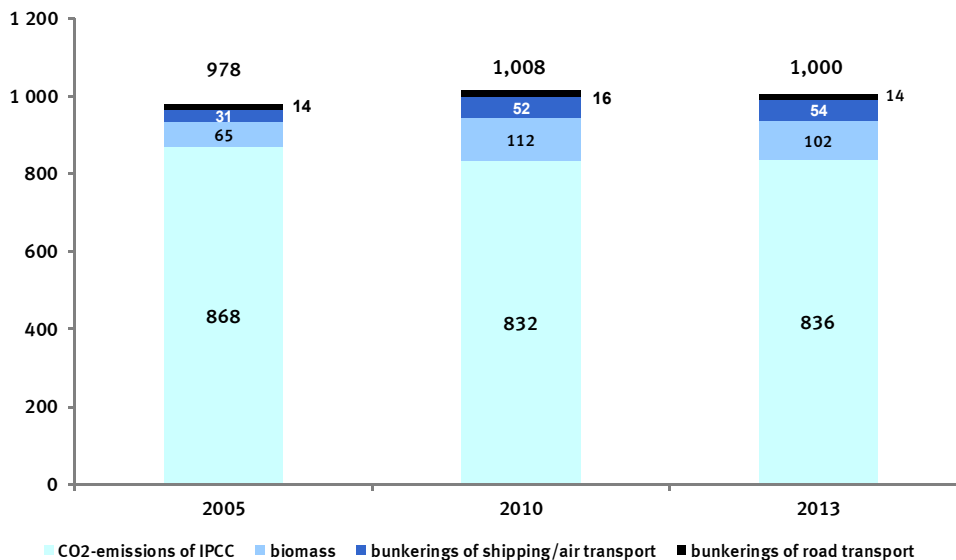
CO₂ emissions by different concepts

In 2013 CO₂ emissions in Germany – within the delimitation of the Environmental-Economic Accounting ⁴ – amounted to 1,000 million tonnes. In 2005 the emissions were at 978 million tonnes. The reason for the slight rise in CO₂ emissions in Germany was an increased energy consumption of biomass with associated CO₂ emissions. Between 2005 and 2013 the emissions from the combustion of biomass increased substantially (2005: 65 million tonnes, 2013: 102 million tonnes).

The emissions within the delimitation of the Environmental-Economic Accounting include in addition to the emissions in the IPCC delimitation ⁵ also emissions from international shipping and aviation – but only those of residential units ⁶. This delimitation also includes CO₂ emissions arising from fuel purchases abroad in road traffic and sea transport by German residents (private households and companies).

CO₂ emissions according to the IPCC concept – have dropped by 3.7 % from 868 million tonnes (2005) to 836 million tonnes (2013) (figure 1).

Figure 1 CO₂ emissions in Germany
mn tonnes



2013 and 2010: data status IPCC 2016, 2005: 2013.

⁴ Including emissions from biomass, from bunkering by residents in international shipping and aviation and from fuel purchased abroad by residents but excluding bunkering of non-residents on the territory.

⁵ IPCC: Intergovernmental Panel on Climate Change. Emissions excluding the position "Land use, land use change, forestry" (LULUCF).

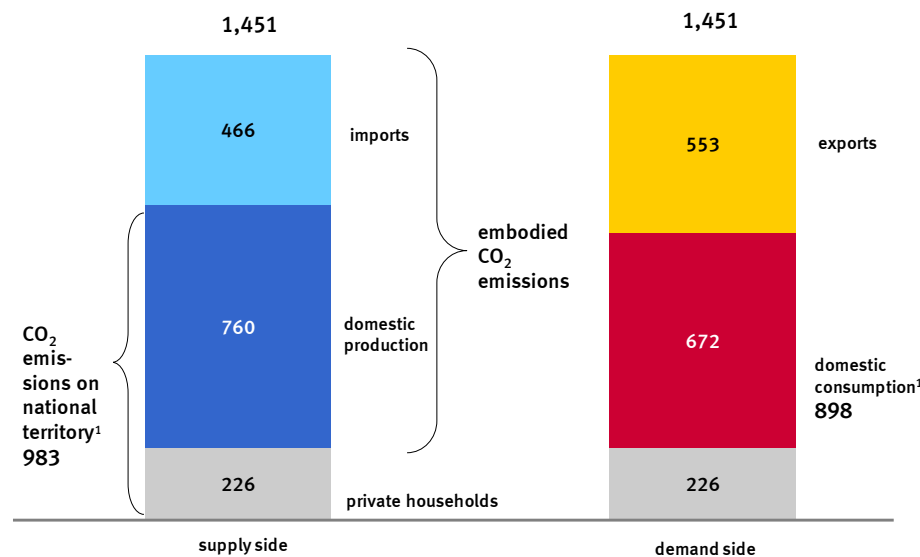
⁶ In international reporting of greenhouse gases all emissions from bunkering by international shipping and aviation in Germany are shown as "figures for information purposes". The level of these emissions is not included in the standardised final record.

In 2013 domestic emissions have totalled 1,000 million tonnes. 775 million tonnes were caused by domestic industries, 226 million tonnes by private households.

In 2013 CO₂ emissions at the production of imports amounted to 466 million tonnes. That is more than half – 61.3 % – of the emissions of domestic origin. Indirect emissions by industries and direct emissions of private households add up to 1,451 million tonnes in 2013. This total is based on measuring and allocating emissions from a production point of view.

Based on the results of the model calculations CO₂ emissions can also be outlined from a consumption point of view (figure 2). Here a distinction is made between emissions to be assigned to domestic consumption and emissions arising from the production of exports.

Figure 2 **Direct and indirect CO₂ emissions in Germany 2013**
mn tonnes



Residents concept, incl. biomass and bunkering.
1 Excl. transport performances of residents abroad.

The emissions related to domestic consumption can be compared with domestic emissions derived from the production point of view. After deducting the CO₂ content of exports (553 million tonnes) from total emissions these results in CO₂ emissions of 898 million tonnes for domestic consumption. This figure is 87 million tonnes below the CO₂ emissions arising on the territory. The reason for the lower CO₂ figure for domestic consumption is the higher emission content of exports compared with imports.

Carbon dioxide emissions and other greenhouse gases

In terms of greenhouse gases in addition to CO₂ emissions, the methane (CH₄) and nitrous oxide (N₂O) emissions are of great importance. By calculating the direct and indirect emissions of these gases, we get the cumulative emissions of the three most important greenhouse gases. In 2013 these amounted to 1,671 million tonnes of CO₂ equivalents. The CO₂ emissions had a share of 87.7 %, CH₄ emissions of 7.8 % and the N₂O emissions of 4.5 % (table 1). For emissions emitted on the territory the share of CO₂ of total greenhouse gases (91.4 %) was higher than for the imports (80.8 %). In terms of imports, CH₄ emissions account for 12.8 %, the N₂O emissions of 6.4 %. Emission sources of CH₄ emissions are mainly the coal industry, the oil and gas extraction (especially pipeline transport), the development of landfill gas in waste

disposal and livestock in agriculture. For N₂O, specific processes in the chemical industry, in the generation of energy, during the combustion of fuels for transport and in fertilization in agriculture play a role.

Table 1 Direct and indirect greenhouse gas emissions 2013

Greenhouse gases	Total	Emissions	
		on the territory	abroad
	mn t CO ₂ equivalent		
	Total		
Carbon dioxide	1,466	1,000	466
Methane	130	56	74
Nitrous oxide	75	38	37
Total	1,671	1,094	577
	share of total in %		
Carbon dioxide	100	68.2	31.8
Methane	100	43.1	56.9
Nitrous oxide	100	50.9	49.1
Sum	100	65.5	34.5
	share of sum in %		
Carbon dioxide	87.7	91.4	80.8
Methane	7.8	5.1	12.8
Nitrous oxide	4.5	3.5	6.4
Sum	100	100	100

Supply and use of CO₂ emissions

From 2005 to 2013 direct CO₂ emissions from the combustion of fuels increased in Germany by 2.3 % from 978 million tonnes to 1,000 million tonnes. In 2013 thereof 226 million tonnes were emitted by households – this was 22.6 % of total direct emissions in Germany – and 775 million tonnes by industries.

In addition to the direct emissions on the territory, emissions generated abroad at the production of German imports are to be considered when talking from a consumer's point of view. These (indirect) emissions have increased by 20.3 % from 387 million tonnes (2005) to 466 million tonnes (2013). The share of these emissions of total supply increased from 28.4 % (2005) to 31.8 % (2013).

Table 2 Direct and indirect CO₂ emissions in Germany

	2005	2010	2013	2013/2005
	mn tonnes			%
Direct emissions on territory ¹ . . .	978	1,008	1,000	2.3
Private households	231	234	226	– 2.3
Industries	747	775	775	3.7
Imports	387	459	466	20.3
Domestic supply	1,365	1,468	1,466	7.4
Private households	231	234	226	– 2.3
Exports	488	545	553	13.4
Goods for domestic consumption	646	689	687	6.3
Consumer goods	413	442	439	6.2
Government purchases, capital formation	234	247	248	6.3
Total use	1,365	1,468	1,466	7.4
	in % of total supply/use			%-points
Direct emissions on territory	71.6	68.7	68.2	– 3.4
Private households	16.9	15.9	15.4	– 1.5
Industries	54.7	52.8	52.8	– 1.9
Imports	28.4	31.3	31.8	3.4
Total supply/use	100	100	100	X
Private households	16.9	15.9	15.4	– 1.5
Exports	35.7	37.1	37.8	2.0
Goods for domestic consumption	47.4	47.0	46.9	– 0.5
Consumer goods	30.3	30.1	29.9	– 0.3
Government purchases, capital formation	17.1	16.9	16.9	– 0.2

1 As defined in Environmental-Economic Accounting (residents concept, incl. emissions from the combustion of biomass).

At the use side exports have the highest emissions and its share in total emissions has risen – from 35.7 % (2005) to 37.8 % (2013). In 2013 the share of consumer goods was 29.9 %. However, direct emissions of households and those of consumer goods together still form the largest source of emissions with 45.3 % of all emissions (2013).

Direct CO₂ emissions of private households and CO₂ content of consumer goods

Direct CO₂ emissions of households arise through the combustion of fuels in road transport and in the area of "housing". These direct emissions have decreased from 231 million tonnes (2005) to 226 million tonnes (2013). The emissions from the consumption of fuels for transportations have decreased by 1.7 %, the consumption of fuels for heating decreased by 2.7%.

Table 3 Direct CO₂ emissions of private households and CO₂ content of consumer goods

	2005	2010	2013	2013/2005
	mn tonnes			%
Direct emissions	231	234	226	- 2.3
Fuels (transport)	103	100	101	- 1.7
Fuels (housing)	128	133	125	- 2.7
CO₂ content of consumer goods . .	413	442	439	6.2
of which:				
Energy products	119	134	133	11.8
Goods	152	151	155	2.0
Services ¹	153	157	151	- 1.7
Total emissions	644	675	664	3.2
	share of total emissions in %			
Direct emissions	35.8	34.6	33.9	X
CO₂ content of consumer goods . .	64.2	65.4	66.1	X
Energy products	18.5	19.8	20.0	X
Goods	23.6	22.3	23.3	X
Services ¹	23.8	23.3	22.7	X
	tonnes per capita			
Total emissions	7.91	8.41	8.24	4.1

1 Incl. trade and transport services.

In 2013 direct emissions accounted for 33.9 % of total direct and indirect emissions of households. Indirect emissions – 439 million tonnes in 2013 – are accumulated to more or less equal portions to the use of energy, products and services. The emissions of energy products arise mainly at the power plants generating electricity for households. Although the emission coefficients – CO₂ emissions per kWh produced – remained almost constant between 2005 and 2013, electricity consumption of households decreased by 2.5 % during that period. Nevertheless, between 2005 and 2013 the consumption of district heating increased very strong by 13.0 %. This has led to a corresponding increase in emissions of heating plants.

The emissions of the service sector also include emissions of the trade and transport industries, which provide services to households at the distribution of goods. The emissions of the service sector have fallen in total by 1.7 %. Emissions however, have changed differently within the service sector. For example, the emissions from the transport industry, in particular because of the rise in emissions from aviation, increased by 4.3 % during this period.

Between 2005 and 2013 price-adjusted purchases of private households in Germany have increased by 5.7 % (table 4). Purchases of imported consumer goods increased from 120 bn EUR to 139 bn EUR (+ 16.3 %). Their share in total purchases accounts for about 10.6 % (2013). Considering only the purchases of products, then the import share is much higher: in 2013 the import share of products (excluding energy) was 32.9 %.

Table 4 Purchases of private households

	Domestic pur- chases ¹	Purchases ²					CO ₂ total
		domestic production and imports	imports		on the territory		
			total	including: products ³	total	including: products ³	
	2000=100	EUR bn					mn tonnes
2005	101.9	1,121	120	102	1,002	186	413
2010	105.0	1,220	115	94	1,105	213	442
2012	107.6	1,288	132	105	1,156	237	440
2013	107.8	1,307	139	106	1,168	217	439
change in %							
2013/2005	5.7	16.5	16.3	4.0	16.5	16.7	6.2
	% of total		% of products		% of total	% of products	
2005	X	100	10.7	35.5	89.3	64.5	X
2010	X	100	9.4	30.5	90.6	69.5	X
2012	X	100	10.2	30.7	89.8	69.3	X
2013	X	100	10.6	32.9	89.4	67.1	X

1 Domestic purchases of private households, price-adjusted, chain-linked index.

2 At basic prices without net taxes; data from the input-output tables.

3 Purchases of goods excluding energy.

In 2013 about 65 % of the emissions from consumer goods – 283 million tonnes – have been generated in Germany, 35 % or 155 million tonnes abroad (table 5). The emissions abroad can be separated in roughly equal parts on emissions for intermediate goods and of finished consumer goods. The emissions of intermediate goods are a portion of total emissions of imported intermediate goods. This portion is linked to intermediate goods that are used domestically at the production of consumer goods.

Comparing the trend of emissions with the change of price-adjusted purchases shows that emissions – both domestically and abroad – have increased, price adjusted purchases by 5.9 %, emissions by 6.3 %. The trends can be influenced either by changes in the composition of purchases by commodity or – when looking at the imports by origin – by changes in the supplying countries.

Table 5 CO₂ content of consumer goods

	CO ₂ content				
	total	domestic production	imports	at the production of	
				intermediate consumption for domestic consumption	final goods
	mn tonnes				
2005	413	278	134	67	68
2010	442	288	154	84	70
2012	440	282	159	88	71
2013	439	283	155	85	71
	change in %				
2013/2005	6.2	1.7	15.6	26.9	4.5
	% of total				
2005	100	67.4	32.6	16.1	16.4
2010	100	65.2	34.8	19.0	15.8
2012	100	64.0	36.0	19.9	16.1
2013	100	64.6	35.4	19.3	16.2

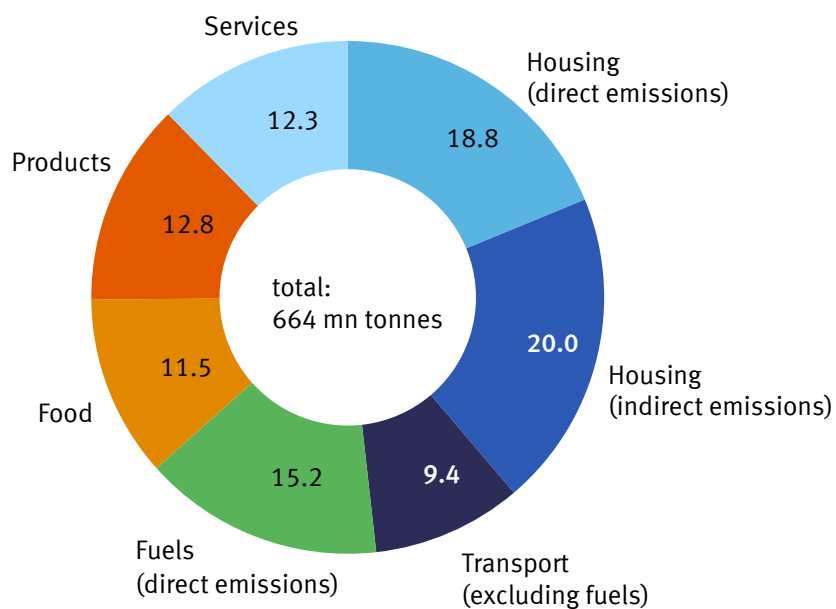
For example, price-adjusted purchases of services showed an increase of 8.6 %, much more than the increase of total purchases⁷. The purchases of everyday consumer goods, however, declined by 4.9 %. Since the production of goods usually requires a higher energy input and thus higher CO₂ emissions than average, a shift of purchases towards services contributes to a reduction in total emissions. However, certain service activities, such as transport activities, also have relatively high specific emissions. Also telecommunications services cause – when involving backward linkages – high emissions.

Direct and indirect emissions can be grouped according to “areas of demand”⁸. About 39 % of the emissions can be assigned to the area of “housing”, another 25 % are assigned to “transport”. These areas already account for more than two thirds of total emissions. Another important area is “food” with a share of 11.5 %. The remaining emissions can be attributed with 12.8 % to miscellaneous products and 12.3 % to the services.

⁷ See Volkswirtschaftliche Gesamtrechnungen (National Accounts), Fachserie 18 Reihe 1.4, 2016, Tabelle 3.3.4.

⁸ Figures according to this grouping show emissions of trade industries at the corresponding product items.

Figure 3 Direct CO₂ emissions of private households and CO₂ emissions of consumer goods by areas of demand 2013
in %



CO₂ emissions of imports by country of origin

In 2013 by far the highest emissions resulting from German imports occurred in China: 36.9 million tonnes, followed by the Netherlands (35.1 million tonnes) and Russia Federation (29.5 million tonnes).

China is second in imports of commodities, but first at CO₂ emissions. This is mainly due to the energy- and CO₂ intensive production of commodities by using a high amount of coal at the generation of electricity. The high CO₂ content of imports from the Netherlands can be explained by the relatively high emission coefficients for the most important import commodities: The Netherlands has the highest shares of imports in the case of agricultural products, food products and basic chemicals. The industries producing these products have relatively high emission coefficients compared to other European countries. In the case of electricity generation – this is the industry that accounts for by far the most emissions – the Netherlands also has relatively high emission coefficients.

Table 6 CO₂ emissions of imports 2013 by country of origin

	CO ₂ emissions					Total imports		
	total			of which		products ¹		
				goods for final use	intermediate consumption			
	mn tonnes	%	rank	mn tonnes		EUR mn	%	rank
Total	465.8	100	X	108.4	357.4	890,393	100	X
Netherlands . . .	35.1	7.5	2	8.0	27.1	88,839	10.0	1
China	36.9	7.9	1	13.2	23.7	74,544	8.4	2
France	25.8	5.5	5	5.8	20.0	63,489	7.1	3
United States . .	25.5	5.5	6	6.4	19.1	48,596	5.5	4
Italy	22.0	4.7	7	5.1	16.9	46,911	5.3	5
Russian Federation . . .	29.5	6.3	3	5.4	24.0	41,245	4.6	6
United Kingdom	20.9	4.5	9	4.6	16.4	39,532	4.4	7
Belgium	17.1	3.7	11	2.6	14.5	38,978	4.4	8
Switzerland . . .	9.0	1.9	12	2.1	6.9	38,411	4.3	9
Austria	18.0	3.9	10	3.6	14.3	37,151	4.2	10
Poland	26.7	5.7	4	6.5	20.3	36,749	4.1	11
Czech Republic	21.6	4.6	8	5.4	16.2	33,114	3.7	12
Spain	8.3	1.8	14	2.0	6.3	23,654	2.7	13
Japan	8.3	1.8	13	2.2	6.1	19,492	2.2	14
Norway	4.5	1.0	16	0.7	3.8	18,071	2.0	15
Sweden	5.7	1.2	15	0.9	4.7	14,582	1.6	16
Brazil	4.1	0.9	17	0.7	3.4	8,885	1.0	17
Sum	318.8	68.5	X	75.3	243.6	672,244	75.5	X
Rest	146.9	31.5	X	33.1	113.8	218,149	24.5	X

¹ Source : Foreign Trade Statistics.

CO₂ emissions of exports

Between 2008 and 2013 CO₂ emissions of exports as a whole rose by 1.6 % from 545 million tonnes to 553 million tonnes. In 2013 domestic production with 338 million tonnes contributes to somewhat more than half (61 %) of these emissions (table 7). The remaining emissions – 215 million tonnes – are attributed to the production of imported raw materials and supplies used at the domestic production of exports. These emissions increased strongly both in absolute terms (+ 12 %) and pro rata. In 2013 these emissions accounted for 39 % of total emissions.

In spite of the rise in the import portion, the domestic manufacture of exports is the most significant source for CO₂ emissions in Germany. In 2013 45 % of all CO₂ emissions from domestic industries arose in the production of exports.

Table 7 CO₂ emissions of exports

	2008	2010	2013	2013/2008
	mn tonnes			%
Exports	544.9	530.7	553.4	1.6
Domestic production	353.2	328.4	338.3	– 4.2
Imported intermediate consumption	191.6	202.3	215.2	12.3
Imports	430.2	459.3	465.8	8.3
Exports – Imports	114.6	71.4	87.6	– 23.6
Domestic production (total emissions)	775.2	760.9	759.8	- 2.0
	in % of domestic production			%-points
Exports from domestic production	45.6	43.2	44.5	– 1.0

The substantial rise in domestic and foreign CO₂ emissions for exports can be explained by a sharp increase of exports between 2008 and 2013 (table 8). Exports at current prices (excluding re-exports) rose by 7.9 % from 2008 to 2013. Price-adjusted exports increased by 11.4 %.

Table 8 Exports

	2008	2010	2012	2013	2013/2008
	Current prices, EUR bn				%
Total exports (fob)	1,166.8	1,066.5	1,242.1	1,259.5	7.9
cif/fob correction ¹	- 2.6	- 2.3	- 2.8	- 3.3	28.7
Final consumption expenditure of non-residents in the territory	25.0	25.4	27.6	28.6	14.5
Re-exports	193.3	162.3	190.8	199.8	3.3
Exports	1,113.3	1,090.1	1,268.3	1,284.7	15.4
Goods	948.7	918.3	1,071.4	1,079.8	13.8
Services	164.6	171.7	196.9	204.9	24.5
Price-adjusted; chained index (2010=100)					
Exports	101.8	100	111.3	113.4	11.4
Goods	103.1	100	111.5	113.1	9.6
Services	95.1	100	110.8	115.3	21.3

1 Fob: free on board, cif: cost, insurance, freight

Source: Federal Statistical Office; Input-Output Accounts

In parallel with the increase of exports domestic industries have increased the amount of imported materials and supplies as a proportion of their intermediate consumption. This share increased from 19.5 % to 20.4 % (table 9). This increase is a main reason for the rise of embodied emissions of imported materials and supplies. Within the industries the manufacturing of chemicals showed a significant rise in the import share with an increase from 23.0 % (2008) to 27.1 % (2013).

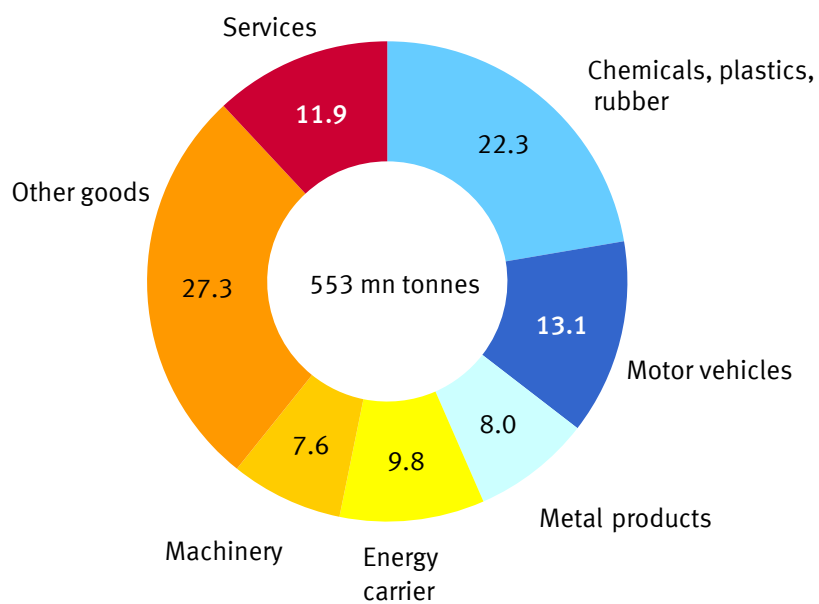
Table 9 Shares for imported intermediate goods by industries

	2008	2010	2012	2013	2013/2008
	%				%-points
Total industries	19.5	19.2	20.7	20.4	1.0
Thereof:					
Manufacture of motor vehicles	23.0	26.7	26.2	27.1	4.1
Manufacture of machinery	24.2	26.8	27.4	26.1	1.9
Manufacture of chemicals	24.2	22.9	25.4	26.8	2.6

Source: Input - Output Accounts (several years of publications)

In the case of exports most emissions arise in the production of chemical and plastic products (22.3 %) and of motor vehicles (13.1 %). The export of metal products with a share of 8.0 % also causes high emissions.

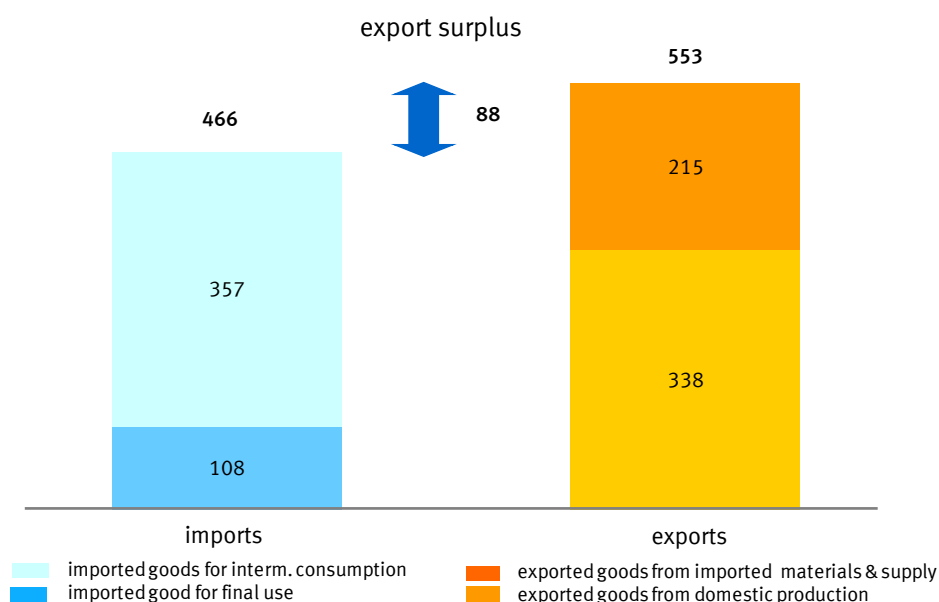
Figure 4 CO₂ emissions of exports in terms of goods 2013
in %



Foreign trade balance of CO₂ emissions

In 2013 CO₂ content of imports was 466 million tonnes (figure 5), CO₂ content of exports was 553 million tonnes. This resulted in a CO₂ surplus of exports over imports of 88 million tonnes.

Figure 5 CO₂ emissions at the production of imports and exports 2013
in mn tonnes



By far the largest portion of CO₂ emissions for imports – 357 million tonnes or just under 77 % of total emissions of imports – applies to materials and supplies. The production of finished goods (consumer goods and capital goods) accounted only for 108 million tonnes of CO₂.

For imports too CO₂ emissions related to (German) exports were the most important driver. In 2013 in the supplier countries 215 million tonnes of CO₂ arose during the production of materials and supplies for German export production. That is 39 % of all CO₂ emissions related to imports. These emissions are influenced by the dynamic growth of exports and the increase in the purchase of imported materials and supplies (see tables 8 and 9).