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Atlas on Environmental Impacts Supply Chains

ENVIRONMENTAL IMPACTS AND HOT SPOTS IN THE SUPPLY CHAIN

Analysis of environmental impacts in eight selected German industries along the global value chain from resource extraction to companies' own sites

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Goals and Structure of the Atlas

Not least by implementing the EU Directive on non-financial reporting in national law, sustainability management is gaining importance for more and more companies. The majority of sustainability challenges borne by many German companies emerge in the supply chain. Companies are therefore called upon to fulfil their social responsibility within their supply chains, as well.

Identifying essential sustainability topics and areas of action in the supply chain represents an important first milestone in sustainable supply chain management for companies. Focus is important in order to be able to use limited human and financial resources as effectively and efficiently as possible. This is often not easy. Both the evaluation of data across national boundaries and the exertion of influence on direct and sub-suppliers to improve their sustainability performance are challenging for companies. This publication seeks to support companies in both areas and help to create transparency regarding the main environmental impacts along the supply chain.

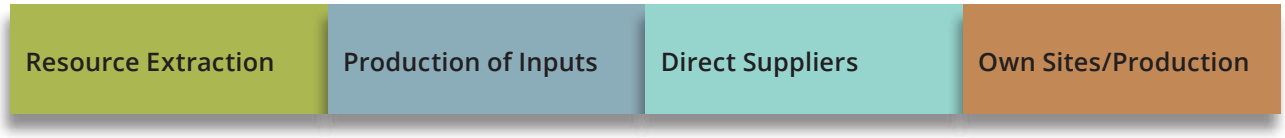
The "Atlas on Environmental Impacts - Supply Chains" shows where and in which world region of the supply chains negative effects can occur for selected sectors with high environmental impacts. This makes "hot spots" visible to the respective industry. Environmental impacts are presented using the four key terms: greenhouse gases, air pollution, water consumption and land use (*Part I*). The results show the environmental impact of the respective industry in Germany with the associated supply chain, i.e. from the extraction of required raw materials through the processing at upstream stages, right up to the direct suppliers (*Part II*). The calculations were performed using an input-output model extended with ecological data (see "Notes on the Methodological Approach" for further information). Based on this, the atlas provides possible measures for designing and optimising a sustainable supply chain (*Part III*).

The selection of the eight German industries took place in multiple steps with significant consideration of data from the Federal Statistical Office.[1] The industries observed in the atlas are:

- Fashion Retailing
- Chemical Industry
- Electronics Industry
- Automotive Industry
- Food Retailing
- Machinery Industry
- Metal Production and Processing
- Paper Industry

1 The basis for the selection was a review of the German business landscape (production and retail; here: food and clothing) on the basis of size/turnover, import share of the services in the supply chain, relevance of environmental impacts and importance for the German economy (including industry structure, public presence).

The atlas considers the upstream value chain, that is, the stages from the extraction of the required raw materials through the processing and on to the direct suppliers. In order to model the environmental impacts in the supply chain, the supply chain has been subdivided into three ideal-type stages, as well as the level of the companies' own sites/production:



Even though supply chains are often more complex and differentiated in practice, this basic structure is found in the vast majority of supply chains. Environmental impacts are presented in the atlas by key area (greenhouse gas emissions, etc.) and supply chain level.

There are two important points to be kept in mind when reading the atlas: First, the fact that the atlas considers the upstream value chain does not mean that major environmental impacts in the selected industries can only occur there. In the context of their environmental and sustainability management, companies from all industries should also consider downstream value chain stages, such as utilisation and disposal phases, in order to improve their environmental and sustainability performance. Second, focusing on key environmental issues does not mean that other environmental or sustainability issues are insignificant. The company should take account of the full range of sustainability issues in the identification and analysis of significant impacts. In addition to other environmental issues, this also includes fields of action such as human rights, labour practices, or fair business and operating practices.[2] A holistic approach like this can allow a company to determine what key issues and areas of action they should focus on. More detailed information on the identification of key areas of action is provided to companies, for example, in the guide "Step by Step to Sustainable Supply Chain Management", which has been published by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Federal Environment Agency.[3]

The authors would like to thank all the experts who have contributed to the creation of the atlas through expert dialogue and background discussions.

Defining Terms

The term "environmental impact" describes the environmental impacts resulting from activities in the supply chain and at the company's own business and production sites in the respective industry. Environmental impacts have been determined using the methodology used in the atlas for the extended input-output modelling for the individual environmental topics. The term is based on "environmental impact" according to DIN ISO 14001: 2015. The term "environmental intensity" describes the turnover-related impacts on the environment along the value chain, i.e. environmental impact per EUR of turnover of an industry. This also applies to the terms "emission intensity" and "water intensity".

2 ISO 26000:2011 offers an overview of the topics central to sustainability management, which can also apply to sustainable supply chain management.
3 Weiss et al. 2017: Step by Step to Sustainable Supply Chain Management. A Practical Guide for Businesses. Berlin: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

Description of the Methodology

The environmental impacts of the eight focus industries were calculated by Systain using an ecologically extended input-output model (Miller et al., 2009). The model is based on statistical data of international value creation flows within the global economy between 82 industries in 43 countries and 5 regions. The model shows the intermediate products (goods, services) that a particular industry purchases from other industries, the countries in which the industry is located, or the countries in which the value chains branch out. This makes it possible, for example, to understand the structures of the supply chains for the German automotive industry or the German chemical industry.

These economic data on the economic links between industries and countries from the input-output tables are linked with environmental data on the respective sectors and countries. This can be used to state how high the environmental impacts of the sector are in the country from which the inputs had been derived. When these data are summarised over the entire supply chain, the environmental impacts along the upstream value chain stages can be quantified.

These so-called ecologically extended input-output models were developed in two important international research projects, the data from which are used for the atlas: EXIOBASE (EXIOBASE2 2007) and WIOD - World-Input Output Database (Timmer et al. 2015).

The economic data underlying the calculations were corrected for the price effects of country-specific inflation. The conversion of currencies into Euros was made using exchange rates from WIOD.

In the study of the eight focus industries, four major environmental impacts were considered: greenhouse gas emissions, air pollution, water consumption and land use. For this purpose, a suitable key indicator was chosen for each. Although other environmental impacts can have particular relevance in the respective sectors, they could not be considered in this study. The calculations provide a factual statement on the environmental impacts of the respective industry along its value chain and make comparisons with other sectors possible.

Notes on the Data

Greenhouse gas emissions: carbon dioxide, methane and nitrous oxide using global warming potential of the IPCC 2013 (WIOD, data from the years 2005-2009, data in CO_2-eq)
Air pollution: nitrogen oxides (NO_x)
Water consumption: so-called blue water (groundwater and surface water, used in the manufacture of a product and not returned to a water body - definition of the Water Footprint Network); the water scarcity indicator from Pfister (Water Scarcity Indices, WSI) was used as the basis (Pfister et al. 2009) of the identification of regions with high water scarcity; high water stress is valid from a WSI value of 0.5
Land use: consideration of the land use by arable and pasture land, productive forest areas and industrial areas. Data from the Food and Agriculture Organization of the United Nations (FAO) and FAOSTAT were used as the basis.

I. Overview of Selected Environmental Topics

The atlas addresses four key areas of environmental protection: greenhouse gas emissions, air pollution, water consumption, and land use.

Greenhouse Gas Emissions

Growing emissions of greenhouse gases (GHG emissions) accelerates climate change (Pachauri et al., 2015). The primary cause is the combustion of fossil fuels for the production of energy. In the use of electricity and heat, CO_2 emissions that contribute to climate change can be found all along the value chain (Erhard et al., 2016: 9, Federal Environment Ministry 2015). In addition, there are other greenhouse gases with much greater impacts than CO_2, such as methane and nitrous oxide, which are generated from agriculture and other sources.

Serious effects are to be expected from unchecked climate change. The melting of the polar caps and species extinction are already scientifically demonstrable (Federal Environment Agency 2016). These partially irreversible consequences again have serious implications for ecosystems and humans, e.g. in drinking water supplies (TEEB DE 2014).

As part of sustainable supply chain management, companies take account of the risks associated with their GHG emissions. In particular, energy-intensive industries face a strict regulatory framework, and it is to be assumed that this will become even more stringent through the addition of regulations like taxes or charges on GHG emissions (CO_2 certificates).

Many governments are working to implement structural change and to strengthen the competitiveness of those companies that consistently reduce their emissions – at both production and product level. High GHG emissions in the supply chain lead to regulatory and cost risks. In addition, physical risks can also occur due to changing climatic conditions, like when extreme weather events occur in regions where (indirect) supplies are active (Erhard et. al 2016: 14). An example of a corresponding business risk would be the loss of production facilities of suppliers in the affected areas (ibid.).

Air Pollution

Air pollution such as nitrous oxide (NO_x) or particulate matter is released by industrial processes or the use of fossil fuels, among other sources, and can have a negative impact on the environment as well as on health.

The World Health Organization (WHO) counted up to 6.5 million deaths resulting from air pollution in 2012, of which about 90% were in emerging and developing countries (WHO 2014). Urban areas are affected in particular, and the guidelines of the WHO are regularly exceeded even in Europe.

Regulatory risks can arise for companies, mainly along their value chain, due to stricter regulations on air pollution. For example, the statutory regulations on fine particulate matter pollution were strengthened in China. This led to a shift in production to other locations and to restricted transportation traffic (Hoffmann 2014).

Water Consumption

The share of ground, spring and surface water (so-called blue water) used amounts to around 70% for agriculture, 19% for industry, and 11% for household use (including drinking water) (FAO 2016).

According to the World Water Report of the United Nations Educational, Scientific and Cultural Organization (UNESCO), an estimated 768 million people have no access to a good water supply (WWAP 2014). The lack of availability and quality aggravates humanitarian crises in many places. By 2050, more than 40% of the world's population will live in areas with severe water stress, i.e. acute water deficiency (ibid.). Production markets in the supply chains of the German economy are also affected by this, e.g. China, India and South Africa (Wagnitz 2014).

Acute water deficiency leads to production loss risks for suppliers. Regulatory risks can also be caused by restrictions on water consumption or increasing water costs in the supply chain (Kraljevic 2012). Finally, there are reputation risks in the case of social conflicts due to water scarcity in regions where (indirect) suppliers are active (Wagnitz 2014, CDP 2016).

Land Use

The term “land use” is used in the atlas to describe the use of land surface areas. This includes the four types of land use: industrial use, use of arable land for harvesting agricultural goods, use of pasture land for the permanent (at least 5 years) cultivation of green fodder plants, and the use of forest areas for the extraction of raw materials. The surface area data in the atlas do not indicate the intensity of different land use forms.

The use of natural areas for cultivation, agriculture or the extraction of raw materials has significantly accelerated in recent decades (Haberl 2015). The growing use of land entails the destruction of natural areas and the loss of ecosystems and biodiversity. The FAO estimates that additional land consumption of approximately 100 million hectares is expected for housing, industry and infrastructure by 2050, of which more than 90% is expected in developing countries (Fritsche et al 2015: 3). Global soil sealing, e.g. for industrial areas, has a lasting damaging effect on soil functions - an almost irreversible process. Agricultural practices that address sustainability issues inadequately can significantly contribute to loss of species, soil erosion and loss of storage and buffering function of soils.

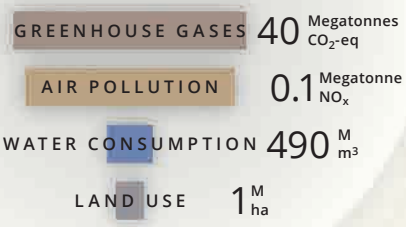
There are also regulatory risks for companies and their supply chains in land use. In addition, the loss of natural areas and the shrinking of habitats can lead to reputation risks for those companies whose supply chains entail a high level of land use.

II. Industry Profiles

Overview

The graphics illustrate the environmental impact of the eight selected German industries with their global supply chains in the four key areas of greenhouse gases, air pollution, water consumption and land use. The results include the company's own sites in Germany, the associated suppliers and upstream stages as well as the extraction of the required raw materials. Detailed information can be found in the respective industry profiles.

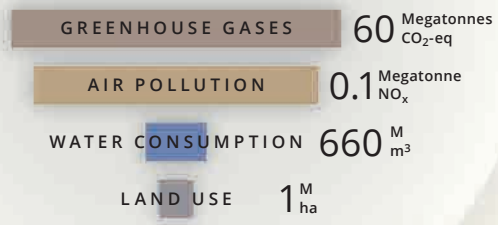
Electronics Industry



Turnover 170 Billion EUR

The electronics industry, with its entire value chain, is one of the less environmentally-intensive industries, both in absolute and revenue-related terms.

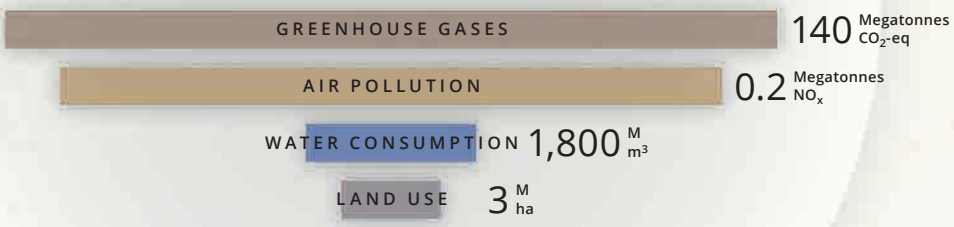
Machinery Industry



Turnover 235 Billion EUR

The machinery industry, despite its size, is one of the sectors with comparatively low environmental impacts along its value chain. In terms of turnover, the machinery industry sector even outperforms the other sectors under investigation.

Automotive Industry



Turnover 450 Billion EUR

The automotive industry performs strongest of the eight sectors in terms of turnover. The absolute environmental impacts along the value chain of this sector are correspondingly high. If the environmental impact is adjusted in relation to turnover, the automotive industry compares favourably with its supply chain.

Food Retailing Sector

The food retailing sector demonstrates the highest environmental impacts of all industries considered here. This sector consumes the most water. The German food retailing sector's global land use of 22 million hectares is equivalent to almost two thirds of the territory of Germany.

GREENHOUSE GASES	110 Megatonnes CO_2-eq
AIR POLLUTION	0.3 Megatonnes NO_x
WATER CONSUMPTION	8,900 M m^3
LAND USE	22 M ha

Turnover 191 Billion EUR

Paper Industry

Turnover 37 Billion EUR

GREENHOUSE GASES	14 Megatonnes CO_2-eq
AIR POLLUTION	0.04 Megatonnes NO_x
WATER CONSUMPTION	320 M m^3
LAND USE	0.5 M ha

The paper industry is the smallest of the industries under investigation. Thus the absolute environmental impact along the value chain is comparatively low. When calculated in terms of sales, however, it is at the upper tier.

Metal Production and Processing

GREENHOUSE GASES	140 Megatonnes CO_2-eq
AIR POLLUTION	0.2 Megatonnes NO_x
WATER CONSUMPTION	700 M m^3
LAND USE	0.5 M ha

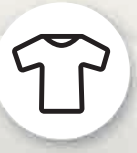
Turnover 205 Billion EUR

Metal production and processing has the highest total GHG emissions in the value chain of the eight industries under investigation. With 0.7 kilograms of CO_2-eq per EUR in turnover, this sector has the highest CO_2 intensity.

The chemical industry is the second largest industry in terms of turnover. The absolute environmental impacts of the entire value chain are correspondingly high. The chemical industry has the second highest water consumption compared to other industries. The global use of land, primarily in the extraction of raw materials, corresponds to the area of Baden-Württemberg.

Fashion Retailing Sector

Turnover 44 Billion EUR



GREENHOUSE GASES	14 Megatonnes CO_2-eq
AIR POLLUTION	0.04 Megatonnes NO_x
WATER CONSUMPTION	600 M m^3
LAND USE	1 M ha

The production of textiles makes its impact in the value chain of the fashion industry. Compared to the other industries, the absolute environmental impacts are in the medium range, but the high environmental intensity of the value chain is reflected when adjusted for turnover.

Chemical Industry

GREENHOUSE GASES	100 Megatonnes CO_2-eq
AIR POLLUTION	0.2 Megatonnes NO_x
WATER CONSUMPTION	2,500 M m^3
LAND USE	4 M ha

Turnover 265 Billion EUR

Specific Environmental Impacts

The absolute environmental impacts of individual industries are related to the size of the respective industry. For example, the environmental impacts of the automotive and chemical industries are usually higher than in the other sectors. Environmental protection activities in the supply chain therefore have great potential for reducing environmental damage.

The consideration of the environmental intensity, i.e. the environmental impacts related to the industry's turnover, shows that there is also a need for action for industries of a smaller size. The paper industry and fashion retailers, in particular, have a high environmental intensity, even if the absolute environmental impacts are comparatively low.

ENVIRONMENTAL IMPACTS OF THE INDIVIDUAL FOCUS INDUSTRIES INCLUDING SUPPLY CHAIN PER EURO OF TURNOVER PER INDUSTRY

rounded values	Greenhouse Gases kg/EUR	Air Pollution g/EUR	Water Consumption l/EUR	Land Use m²/EUR
Fashion Retailing Sector	0.3	0.8	13.6	0.3
Chemical Industry	0.4	0.7	9.5	0.2
Electronics Industry	0.3	0.5	3.0	0.1
Automotive Industry	0.3	0.6	4.1	0.1
Food Retailing Sector	0.6	1.6	46.6	1.2
Machinery Industry	0.2	0.5	2.8	0.0
Metal Production and Processing	0.7	0.9	3.4	0.0
Paper Industry	0.4	1.0	8.5	0.1

COLOUR CODE

- Focus Industries with the Highest Values
- Focus Industries with Intermediate Values
- Focus Industries with the Lowest Values

The food retailing sector has both high specific and absolute environmental impacts. Especially in the case of water consumption, the value chain for food retailing is many times higher than the consumption of other industries. It consumes 47 litres of water per EUR of turnover. As a result, food retailing has by far the highest water intensity along its value chain. Fashion retailing also has high water intensity, with almost 14 litres per EUR of turnover, from raw material extraction to the production site and on to the point of sale in Germany. Much of the water is consumed in regions with water stress, i.e. with regional or seasonal water scarcity.

The highest GHG emissions per EUR of turnover are caused by the metal production and processing industry. It is also in absolute terms the largest source of GHG emissions among the eight sectors under investigation. With 0.6 kilograms of CO_2-eq, food retailing also has a high level of greenhouse gas emissions per EUR of turnover.

Environmental Impacts of the Supply Chain in Relation to Companies' Own Sites

In all industries, the upstream value chain, from raw material extraction through the individual processing stages to direct suppliers, plays a significant role in the environmental impact. Environmental protection measures must therefore be initiated not only at companies' own sites, but also geared towards the supply chain.

Greenhouse gas emissions in the supply chains of the automotive industry, machinery industry and food retailing are about ten times higher than at their own locations in Germany. A similar picture emerges for pollutant emissions. 20-30% of the emissions are generated at the level of the direct suppliers within each sector. Companies can already address a relevant share of emissions across the entire value chain by applying measures that involve their own suppliers.

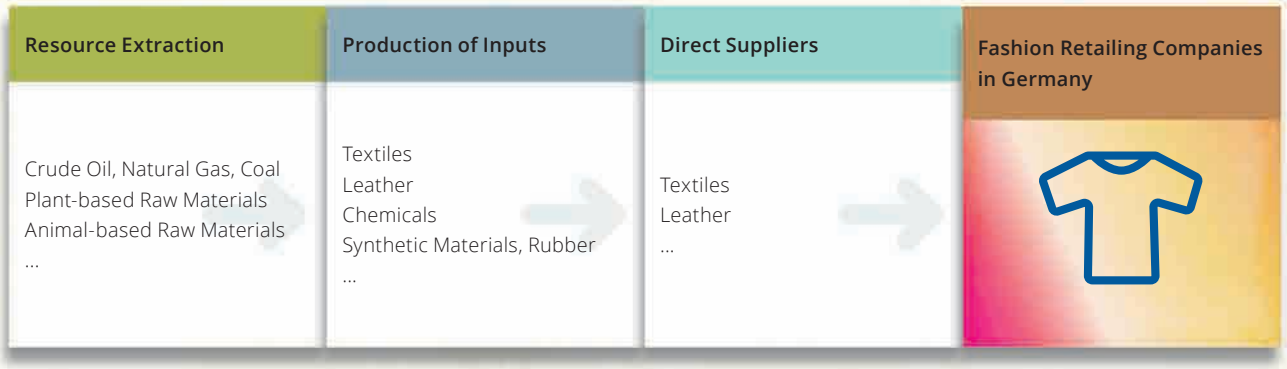
In clothing and food retailing, the supply chain accounts for almost 100% of water consumption. A significant proportion is consumed in regions with high water stress, i.e. in regions with local or seasonal water scarcity, as illustrated in the industry profiles.

Fashion Retailing

44 Billion EUR turnover
450,000 Employed
25,000 Companies

German Federal Statistical Agency,
Sparkasse Finanzgruppe Branchendienst;
Values for 2015

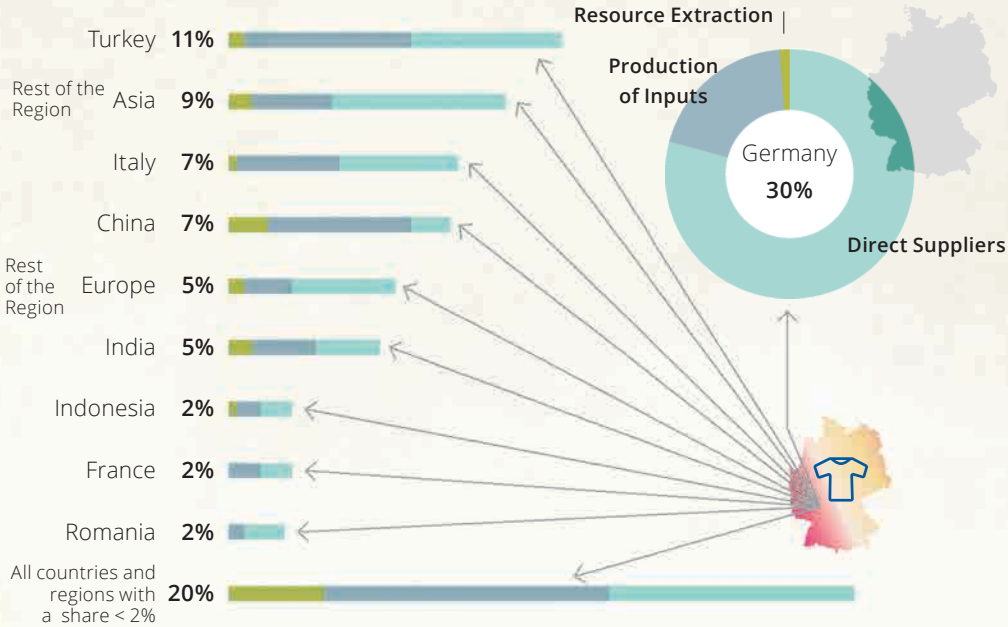
The Structure of the Value Chain



The value chain of the fashion retailing sector is linearly structured - in contrast to supply chains that are structured by components manufacturing, such as in the automotive industry and machinery industry. In addition, the supply chain is characterised by a few industries: mainly the textile industry, including the leather industry. The agricultural production of natural fibres plays an important role in the extraction of raw materials.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

A majority of the value added in the supply chain (70%) takes place outside Germany. Important import countries and regions are Turkey and Asia. In contrast to other industries, only a few supply chains are distributed across Europe.



The Environmental Impacts of the German Fashion Retailing Sector Along the Value Chain

The production of textiles is significant in the value chain of the fashion retailing sector. Compared to the other sectors analysed, the absolute environmental impacts are in the medium range, but the high environmental intensity of the industry is reflected in relation to the turnover.

The environmental impacts of the fashion retailing sector are many times higher for the supply chain than at the companies' own locations. Both the GHG and NO_x emissions are nearly tenfold in the supply chain. One-fifth of each is generated at the level of direct suppliers. Almost half of the emissions are attributable to the production of preliminary products. Water consumption in the supply chain is mainly caused by raw material extraction. Land use almost exclusively concerns raw material production.

Distribution of Environmental Impacts along the Supply Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Fashion Retailing Companies (own sites)	Overall
Greenhouse Gases	28%	44%	19%	9%	**14** Megatonnes CO_2-eq
Air Pollution	25%	47%	20%	8%	**0.04** Megatonnes NO_x
Water Consumption	84%	9%	7%	0%	**600** M m^3 Water
Land Use	98%	1%	1%	0%	**1.0** M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.3** kg CO_2-eq
Air Pollution	**0.8** g NO_x
Water Consumption	**13.6** Litres
Land Use	**0.3** m^2

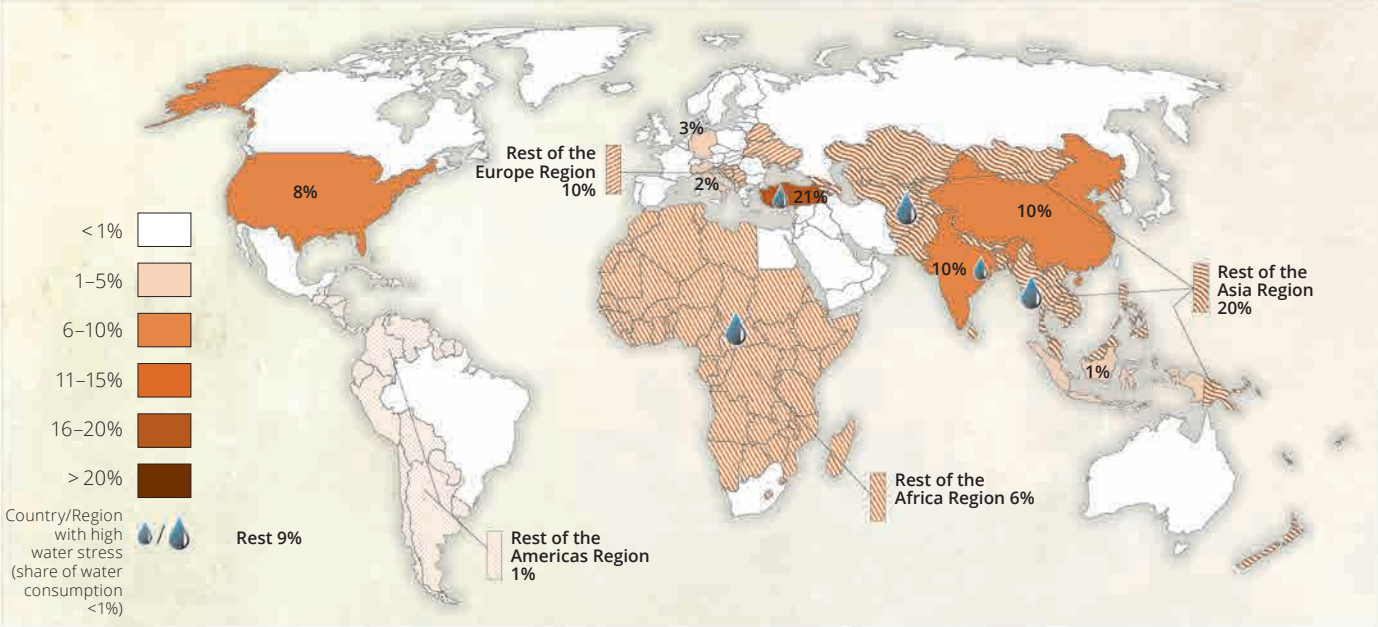
In terms of turnover, nearly 14 litres of water per EUR of turnover are consumed in the value chain of the fashion retailing sector. This is the highest value among the eight industries studied, after food retailing. This sector also has the highest turnover-adjusted value, along with food retailing, in terms of land use.

Given the high water intensity of the fashion retailing sector, this environmental topic is described in detail in the following.

Focus:
Water Consumption

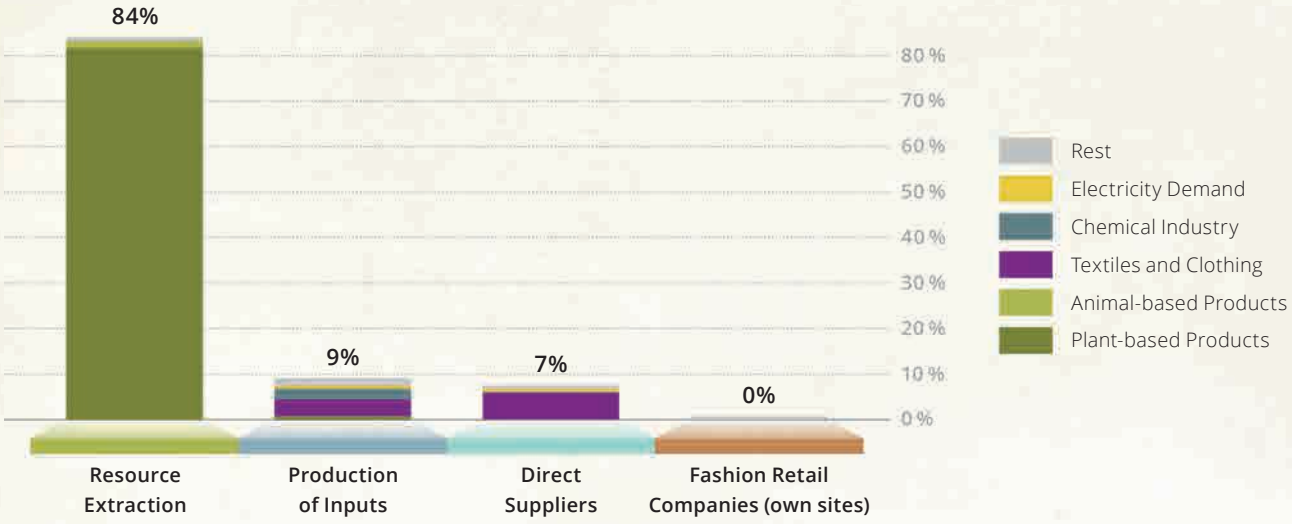
Distribution of Water Consumption in the Value Chain of the German Fashion Retailing Sector

By country



Nearly two-thirds of water consumption in the value chain comes from countries and regions with high water stress, including Turkey and Asia. One-fifth of the water is consumed in Turkey, predominantly for cotton growing.

By industry



More than 80% of water consumption in the global value chain is caused by the production of raw materials, especially in the agricultural production of cotton. Approximately one-tenth is attributable to textile production.

Further Environmental Impacts

Greenhouse Gas Emissions

Over 90% of GHG emissions are generated in the supply chain. More than a third is attributable to electricity consumption along the textile value chain. One tenth is attributable to direct emissions in textile production, for example through heat processes. The extraction of animal or vegetable raw materials (for example, leather or cotton) accounts for a further one-tenth of GHG emissions.

Important countries in which GHG emissions are generated in the supply chain are China and India.

Air Pollution

As with the GHG emissions, over 90% of the NO_x emissions are also caused in the supply chain. The bulk of this is due to transport and the purchase of electricity along the value chain. Almost one-fifth of pollutant emissions are attributable to the production of plant fibres.

Countries with the highest NO_x emissions in the value chain of this industry are Germany, China and India.

Land Use

Land use almost exclusively concerns raw material production. For the extraction of plant raw materials like cotton and animal raw materials like leather, nearly one million hectares of land is claimed. Nearly half of the land use is located in Asia, including China.

» CONCLUSION

The reduction of high water intensity in the textile value chain is an important area for action. Per EUR of turnover of the German fashion retailing sector, nearly 14 litres of water are consumed in the upstream value chain stages, of which more than two thirds are in regions with high water stress. More than 80% of the water consumption is attributable to cotton growing, and about 10% to textile production.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guideline from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference*
- Guide to Environmental Standards in the Textile and Shoe Industry from the Federal Environment Agency, (in German only) *www.umweltbundesamt.de*
- Partnership for Sustainable Textiles *www.textilbuendnis.com*
- Environmental Performance Tool from the CPI2 Initiative *www.cpi2.org*
- Guidelines from the Zero Discharge of Hazardous Chemicals (ZDHC) group *www.roadmaptozero.com*
- Bluesign System for producing sustainable textiles *www.bluesign.com*
- Global Organic Textiles Standard (GOTS) *http://www.global-standard.org*
- Better Cotton Initiative (BCI) *http://bettercotton.org*
- Cotton made in Africa (CmiA) *www.cottonmadeinafrica.org/de*

Chemical Industry

265 Billion EUR Turnover
830,000 Employed
5,200 Companies

German Federal Statistical Agency;
Values for 2015

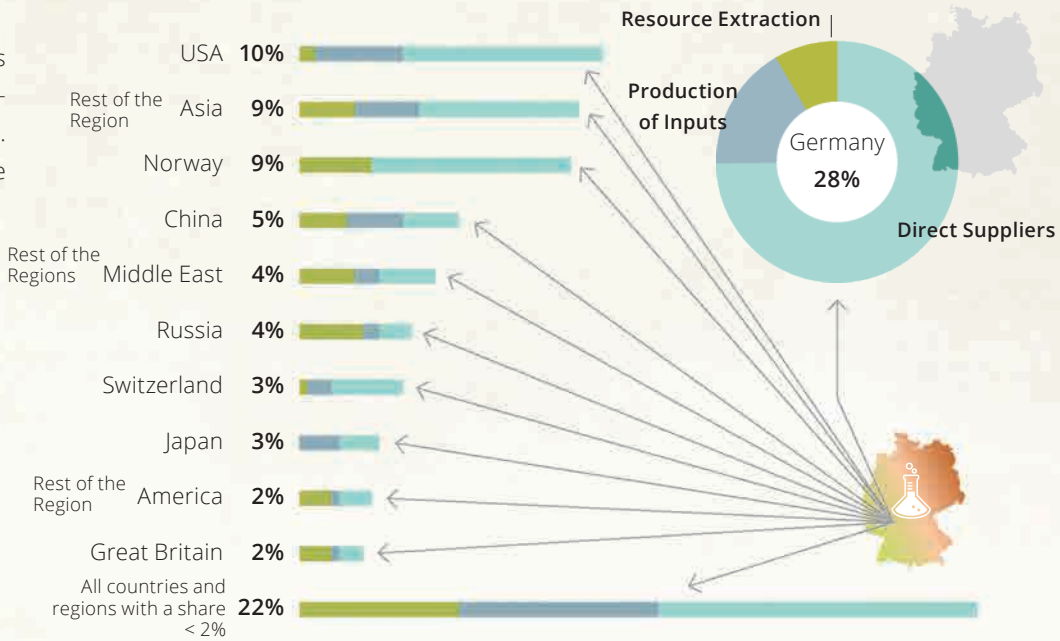
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Chemical Industry Companies in Germany
Crude Oil, Coal Precious Metals Copper Wood, Plant and Animal Resources ...	Chemicals Plastic, Rubber Petrochemical Precious Metals ...	Chemicals Plastic, Rubber ...	

The chemical industry obtains numerous preliminary products and services from within its own industry. At the preliminary stage, petrochemicals are important. Apart from the extraction of crude oil, natural gas, coal and metals, agricultural goods also play an important role when it comes to raw materials.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

The chemicals industry exhibits a high import share (70%) compared to the other industries. Import countries include the USA, Norway, and Asian ones.

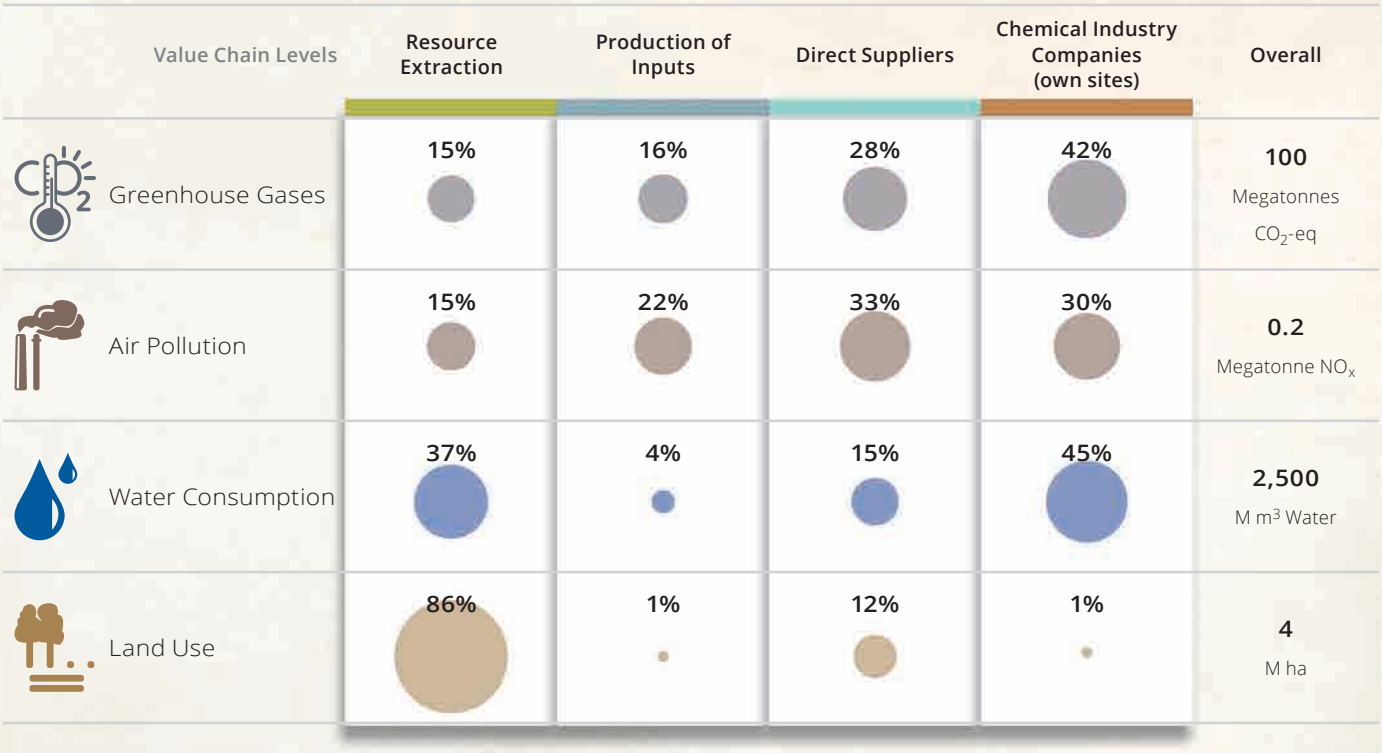


The Environmental Impacts of the German Chemical Industry along the Value Chain

The chemical industry is the second largest industry in terms of turnover. The absolute environmental impacts of the entire value chain, particularly in terms of water consumption and land use, are correspondingly high.

The environmental impacts of the chemical industry are significantly higher in the supply chain than at the companies' own sites. Slightly more than half of the GHG emissions are attributable to the supply chain. In the other industries, the share of the supply chain is usually higher. The proportion of air pollutant emissions is about one-third. Notable is the high proportion accounted for by direct suppliers in terms of total GHG and NO_x emissions (about one third each). Water consumption is just as high in the supply chain as at companies' own sites. More than one-third of the water is consumed in the extraction of raw materials. The land use is exclusively accounted for by raw material production.

Distribution of Environmental Impacts along the Value Chain



Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.4** kg CO_2-eq
Air Pollution	**0.7** g NO_x
Water Consumption	**9.5** Litres
Land Use	**0.2** m^2

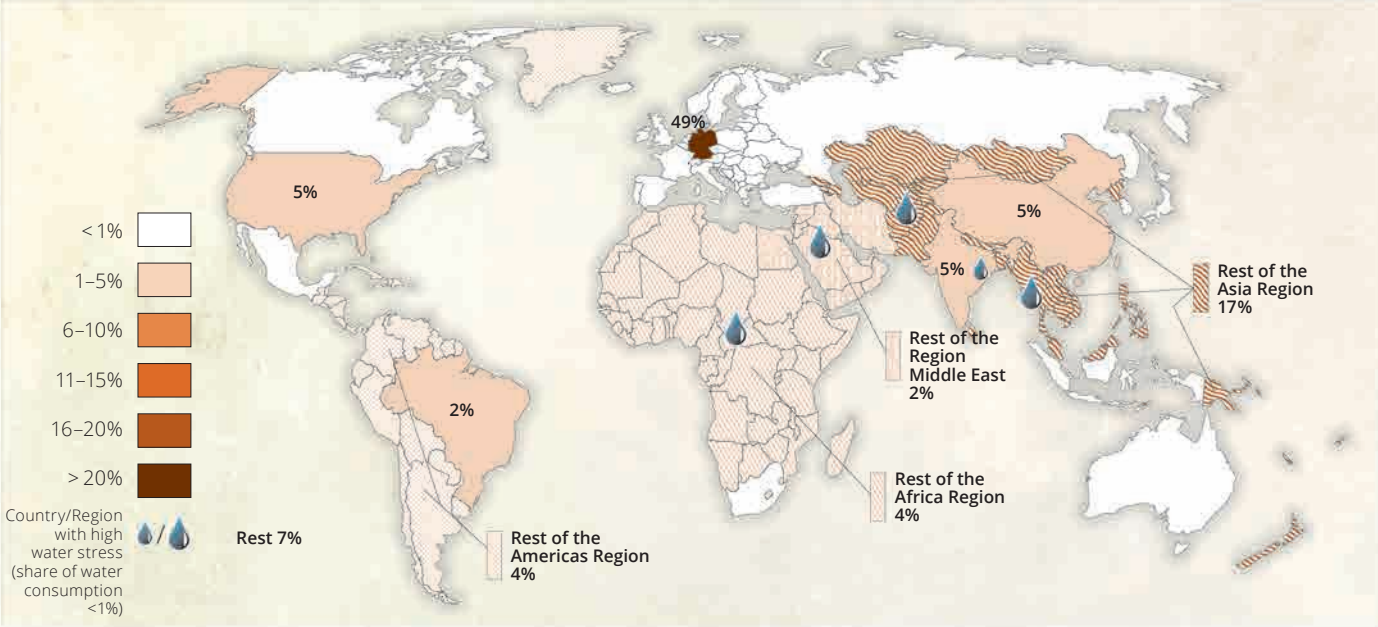
In relation to turnover, the chemical industry is in the upper ranks compared to the other industries under investigation. 9.5 litres of water are consumed per EUR of turnover, corresponding to the third-highest value after clothing and food retailing. It is also worth mentioning the high share of its own sites in GHG emissions and water consumption (just under half) as well as in NO_x emissions (one-third).

Due to its high value, water consumption in the value chain of the chemicals industry is described in detail below.

Focus:
Water Consumption

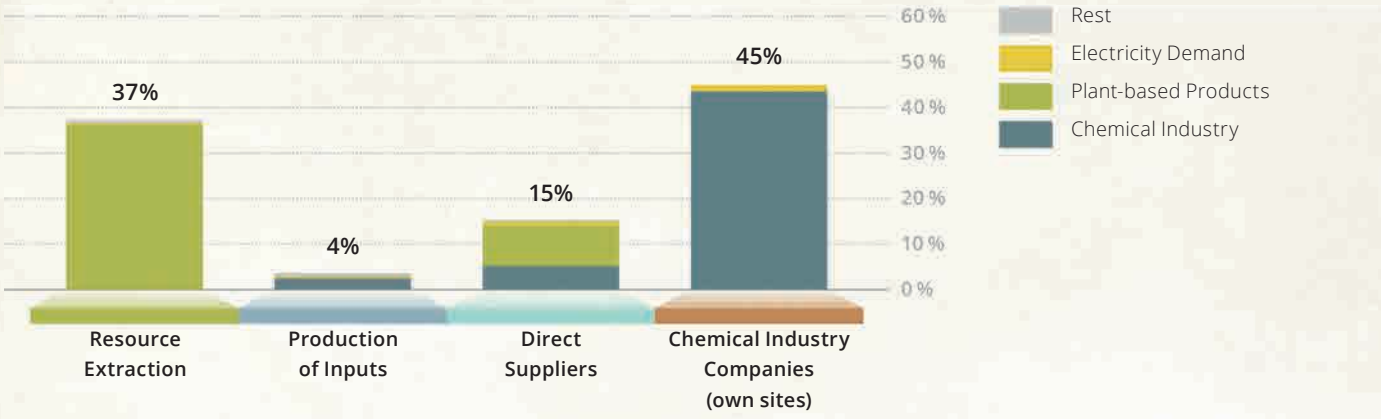
Distribution of Water Consumption in the Value Chain of the German Chemical Industry

By country



Almost half of the water in the value chain is consumed in Germany, mostly at companies' own sites in the chemical industry. The calculations showed that just under a fifth was due to the extraction of raw materials in Asia. Overall, about a third of water consumption in the value chain is attributable to regions with high water stress.

By industry



Half of the water consumption in the global value chain of the chemical industry is directly attributable to the industry itself, with the highest share attributable to chemical plants in Germany. Another driver is the agricultural sector, with its production of agricultural raw materials.

Further Environmental Impacts

Greenhouse Gas Emissions

Over 40% of the GHG emissions originate at the chemical industry's own sites. This means that the proportion is higher than in the other sectors studied (exception: paper industry).

Along with the suppliers from the own industry, the chemical industry itself generates about 50% of the GHG emissions along the value chain. The emissions from the other upstream industries are less than 5%. The share of electricity generation in total emissions is lower than in the other sectors in this study. Due to the high share of GHG emissions, the share of electricity generated in total emissions is negligible compared to the other sectors.

Over half of the emissions originate in Germany. Another important emitter, with just under 10%, is China.

Air Pollution

About 40% of NO_x emissions are caused directly by companies in the chemical industry both at their own sites and in the upstream value chain. Further drivers are transport and the electricity supply along the value chain (one-fifth each).

The majority of NO_x emissions are generated within Germany (about 40%). Other important polluting regions are the USA (over 10%) and Asia.

Land Use

Land use is attributable almost exclusively to raw material extraction (about 90%). The main drivers are plant and animal products, which together account for over 90%. Major regions are Asia and Africa (about one-fifth each). China and the regions of South and Central America are also relevant.

» CONCLUSION

The German chemical industry has the second highest consumption of all eight industries under consideration. Measures to reduce water consumption are therefore significant, especially since one-third of the water is consumed in regions with high water stress. This is due to the extraction of plant raw materials. Half of the water is consumed within Germany, both at companies' own sites, as well as at the sites of direct suppliers and agricultural producers.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guidelines from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference*
- Environmental, Health, and Safety Guidelines from the World Bank *www.ifc.org/ehsguidelines*
- Guide to the Chemicals Sector CTV057 from the Carbon Trust *www.carbontrust.com*
- Sustainability Portal CHEMIE3 of the German Chemicals Industry *www.chemiehoch3.de*
- Portal of the International Councils of Chemical Associations (ICCA) *www.icca-chem.org/energy-climate*
- Industry Initiative: Initiative Together for Sustainability *http://tfs-initiative.com*

Electronics Industry

170 Billion EUR Turnover
700,000 Employed
4,100 Companies

German Federal Statistical Agency;
Values for 2015

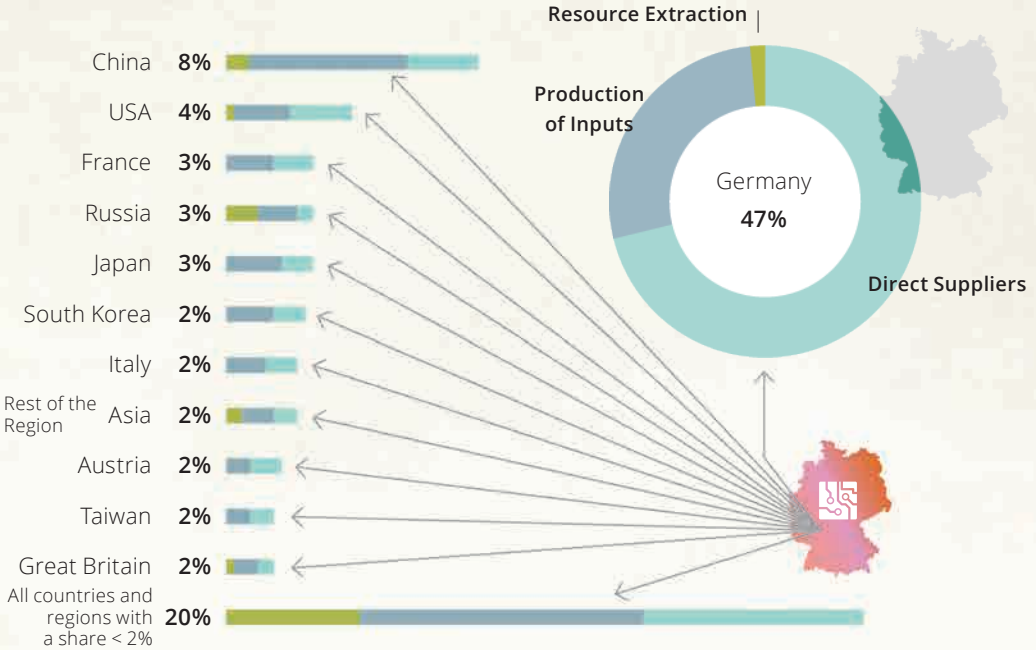
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Electronics Industry Companies in Germany
Crude Oil, Natural Gas, Coal Iron Precious Metals Copper Lead, Tin, Zinc, Nickel ...	Metal inputs Precious Metal inputs Chemical inputs Plastic, Rubber Electronics Machinery Industry ...	Metal inputs Aluminium inputs Copper Chemical inputs Plastic, Rubber Electronics Machinery Industry ...	

The (indirect) suppliers of companies in the electronics industry come mainly from the metalworking industries, the chemical industry, as well as from the electronics industry. The machinery industry and the plastics processing industry also play a major role.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

The import share of the German electronics industry is over 50%. Important import countries are China, the USA and France. Russia plays an important role in the supply chain with regard to raw material production.



The Environmental Impacts of the German Electronics Industry along the Value Chain

The environmental impacts of the electronics industry and its entire value chain are often lower compared to the other sectors of this study, both in absolute terms and in relation to turnover.

The environmental impacts in the supply chain of the electronics industry are significantly higher abroad than at companies' own sites in Germany. Approximately 85% of GHG emissions are generated in the supply chain. Half of this is attributable to the production of inputs. The proportion of air pollutant emissions accounted for by the supply chain is even higher (90%). Water consumption in the supply chain is nearly twice as high as at the companies' own sites. It is one-fifth of the total consumption at each step. Land use almost exclusively concerns raw material production.

Distribution of Environmental Impacts along the Value Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Electronics Industry Companies (own sites)	Overall
Greenhouse Gases	10%	50%	26%	14%	**40** Megatonnes CO_2-eq
Air Pollution	8%	55%	28%	9%	**0.1** Megatonnes NO_x
Water Consumption	23%	23%	16%	39%	**490** M m^3 Water
Land Use	89%	4%	4%	3%	**1** M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.3** kg CO_2-eq
Air Pollution	**0.5** g NO_x
Water Consumption	**3.0** Litres
Land Use	**0.1** m^2

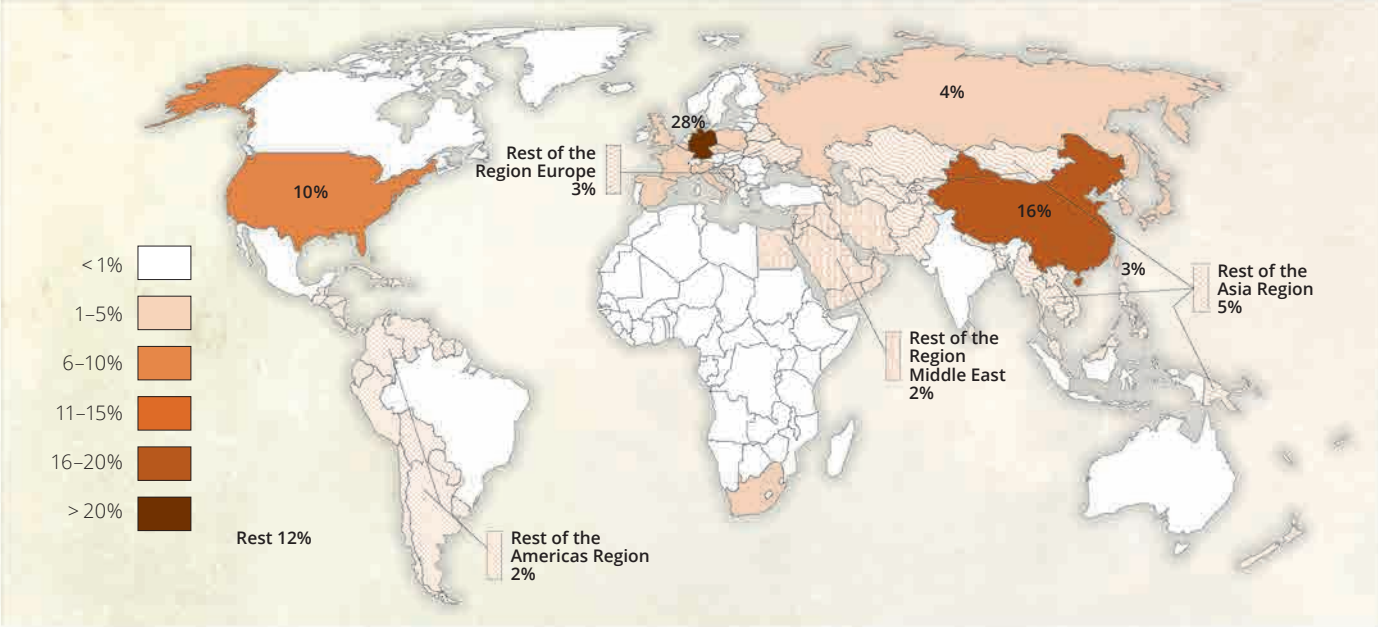
Compared to the other sectors, environmental impacts are relatively small. Per EUR of turnover, 0.3 kg of GHG emissions are generated across the value chain. Water consumption from the raw material extraction all the way to companies' own sites adds up to 3 litres per EUR of turnover. Approximately two-thirds of these relate to the supply chain.

Because of their high share in the supply chain, the air pollution in the value chain is described in detail below.

Focus:
Air Pollution

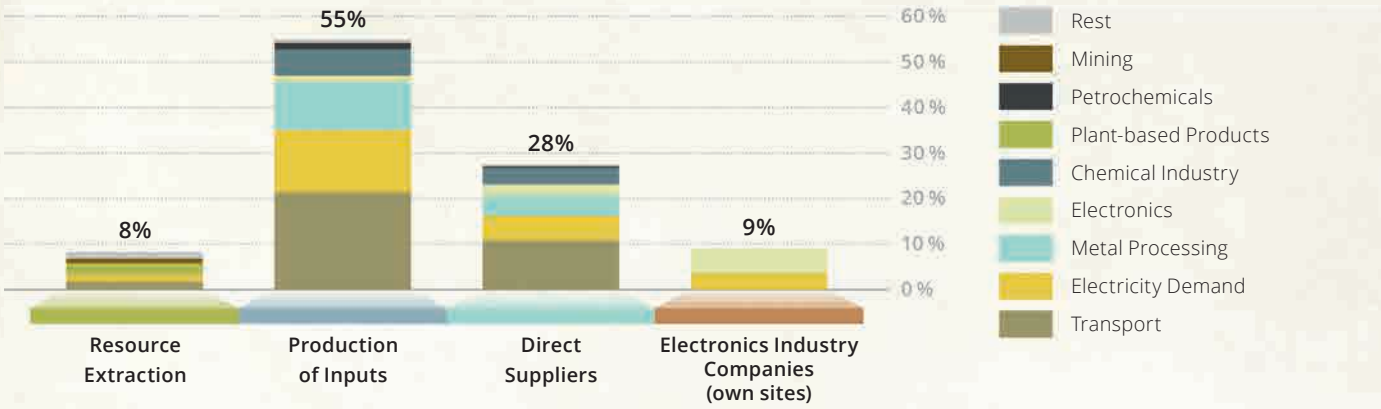
Distribution of Air Pollution in the Value Chain of the German Electronics Industry

By country



Germany accounts for the largest share of NO_x emissions in the value chain of the domestic electronics industry. They are created both at companies own sites, as well as at the stage of direct suppliers and indirect suppliers from within Germany. High shares of NO_x emissions also occur in the supply chain, which branches off to China and the USA.

By industry



One-third of the NO_x emissions are caused by transport, especially at the stage of 'other processing'. The emissions generated by the electricity consumption of producers account for a quarter of the NO_x emissions. Furthermore, relevant industries in the supply chain that cause nitrogen oxide emissions are metal processing companies, the chemical industry and (indirect) suppliers from the electronics industry.

Further Environmental Impacts

Greenhouse Gas Emissions

More than 85% of the GHG emissions are generated within the supply chain. Half of the emissions are related to the production of inputs. Overall, about one-third of the GHG emissions are caused by electricity used along the value chain. Metal processing suppliers and indirect suppliers account for about a quarter of total emissions. Other polluters in the supply chain are the chemical, electronics and transportation sectors, each with a tenth.

As in the case of NO_x emissions, supply chains leading to China account for a disproportionate share of GHG emissions (about one-fifth).

Water Consumption

The highest share of water consumption is accounted for by the electronics industry itself. Approximately one-fifth of the consumption is divided between the direct suppliers, the production of inputs, and the extraction of raw materials.

In the regional distribution, the electronics industry consumes the most water (about half) in Germany, mainly at companies' own sites. About 15% of water consumed in the supply chain is consumed in China. Approximately 15% of the global water consumption in the supply chain is in regions with high water stress, especially in the production of raw materials in Asia and Africa.

Land Use

Nearly 90% of land use is related to raw material extraction. China accounts for the largest share of this.

» CONCLUSION

An important environmental issue in the supply chain of the electronics industry is air pollution. The total NO_x emissions from the supply chain are about 10 times higher than the emissions from companies' own sites. More than half of the emissions are attributable to the production of inputs. Implementing measures in the transportation chain and reducing electricity consumption by (indirect) suppliers are recommended, as most emissions are generated in these areas. Other drivers are suppliers in the metalworking and chemical industries.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guides from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference*
- Environmental, Health, and Safety Guidelines from the World Bank *www.ifc.org/ehsguidelines*
- Guidance Documents of the Electronic Industry Citizenship Coalition (EICC) *www.eiccoalition.org*
- Guidelines of the International Council on Mining and Metals (ICMM) *www.icmm.com*
- Standards of the Aluminium Stewardship Initiative (ASI) *https://aluminium-stewardship.org*
- Tool E-TASC from the Global e-Sustainability Initiative *http://gesi.org/e-tasc*

Automotive Industry

450 Billion EUR Turnover
940,000 Employed
1,600 Companies

German Federal Statistical Agency;
Values for 2015

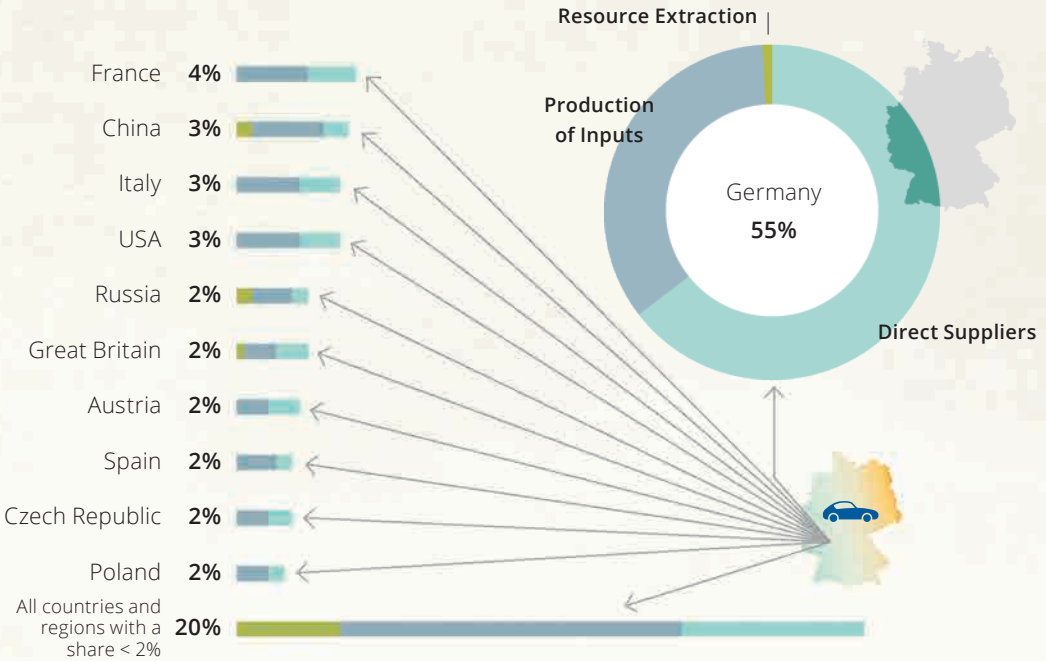
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Automotive Manufacturers in Germany
Crude Oil, Natural Gas, Coal Copper Precious Metals Iron Ore Lead, Tin, Zinc, Nickel Wood ...	Metal Inputs Precious Metal Inputs Chemical Inputs Electronics Machinery Industry Automotive Manufacture Glass Textiles Plastic, Rubber ...	Metal Inputs Electronics Machinery Industry Automobile Manufacture Plastic, Rubber Aluminium ...	

In addition to the manufacture of automobiles, the industry also includes rail and aircraft manufacturing. The value chain of the automotive industry is characterised by a broad mix of industries in the supply chain, which mainly includes metal processing, the plastics and electronics industries, as well as the machinery industry.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

The import share of the German automotive industry is less than 50%. France, China, Italy and the USA play an important role in the supply chain. China is an important market for input products.



The Environmental Impacts of the German Automotive Industry along the Value Chain

The automotive industry is the highest-performing sector among the eight sectors in terms of turnover. The overall environmental impacts along the value chain are correspondingly high.

The environmental impacts are significantly higher in the supply chain than at companies' own sites. Approximately 90% of the GHG emissions are generated in the upstream stages, with just under one-third of emissions attributable to direct suppliers. More than half of the GHG emissions are generated by the production of input products. In terms of air pollutant emissions, the share accounted for by the supply chain is even slightly higher. Water consumption is divided with one-fifth each to the individual stages of the value chain, while water consumption companies' own sites accounts for almost 40%. Land use almost exclusively concerns raw material production.

Distribution of Environmental Impacts along the Value Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Automotive Manufacturers (own sites)	Overall
Greenhouse Gases	8%	54%	28%	10%	140 Megatonnes CO_2-eq
Air Pollution	7%	57%	30%	6%	0.2 Megatonnes NO_x
Water Consumption	21%	23%	18%	38%	1,800 M m^3 Water
Land Use	91%	4%	3%	2%	3 M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.3** kg CO_2-eq
Air Pollution	**0.6** g NO_x
Water Consumption	**4.1** Litres
Land Use	**0.1** m^2

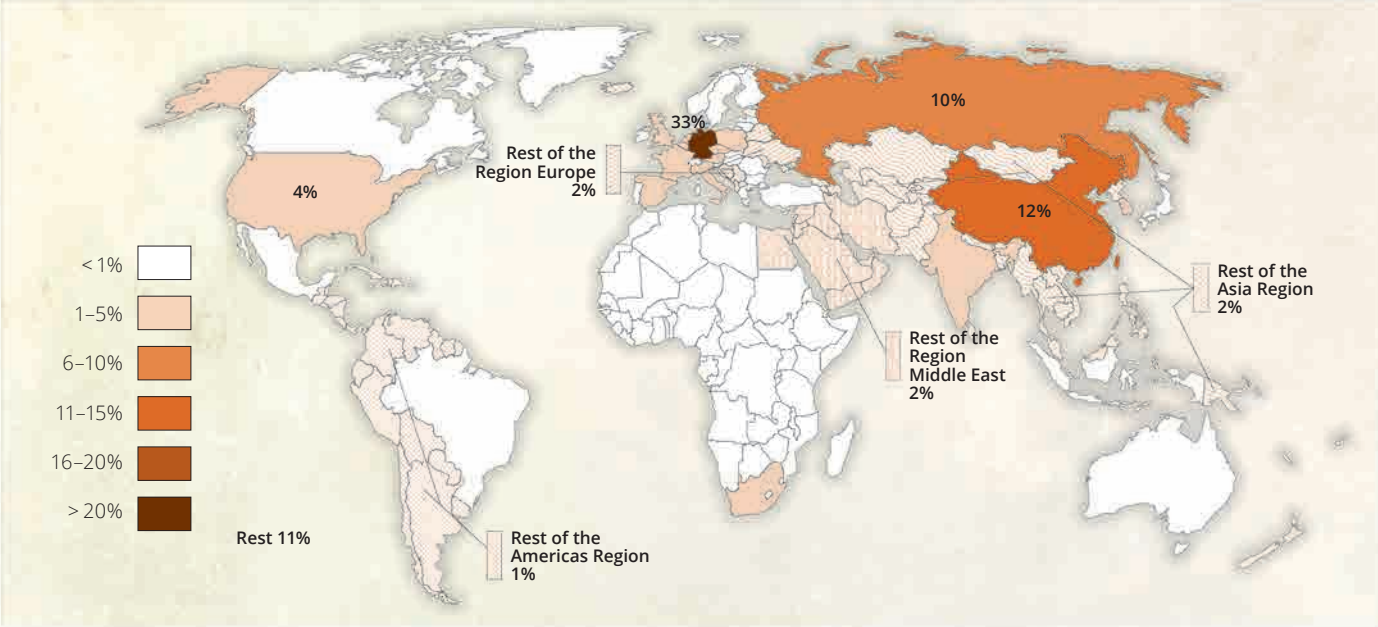
The environmental impacts of the automotive industry relative to turnover are rather low compared to the other industries. Per EUR of turnover, 0.3 kg of GHG emissions are generated across the entire value chain. The majority of this is attributable to the supply chain. Water consumption, from the stage of raw material production up to the company's own sites, amounts to 4.1 litres per EUR of turnover. About two-thirds of this amount is consumed in the supply chain.

Since CO_2 is an important key indicator for the automotive industry, the following section describes the GHG emissions along the value chain.

Focus:
Greenhouse Gas Emissions

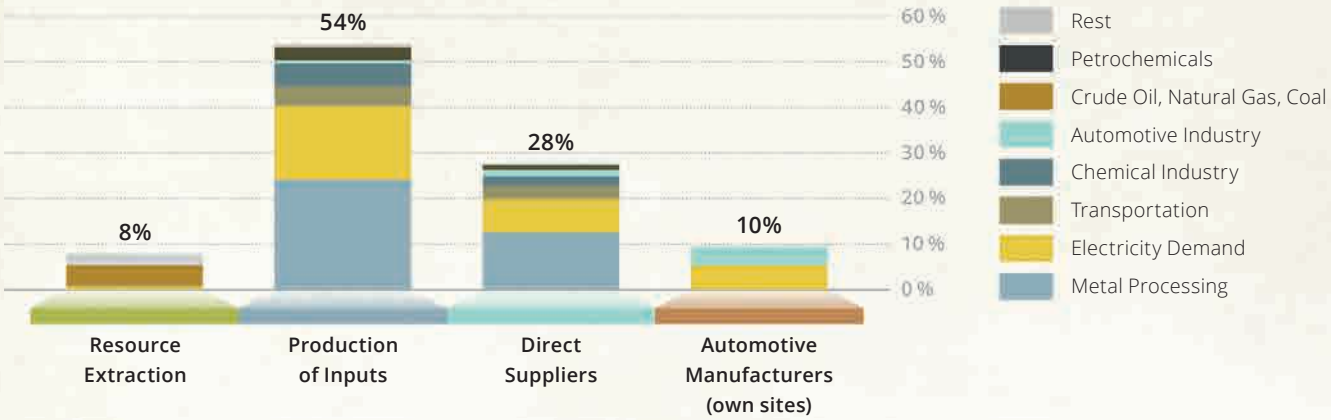
Distribution of Greenhouse Emissions in the Value Chain of the German Automotive Industry

By country



The largest share of GHG emissions in the value chain is generated within Germany, both at companies' own sites as well as at direct and upstream suppliers within Germany.
The analysis shows that China and Russia are also relevant within the supply chain, in particular in terms of the electricity consumption of direct and indirect suppliers (China) and in the processing of metals at the stage of input products (China and Russia).

By industry



A significant driver of GHG emissions in the automotive supply chain is the metalworking industry: its process emissions account for more than one-third of total emissions. Emissions generated by the electricity consumption of producers also account for just under a third.

Further Environmental Impacts

Air Pollution

One-third of the NO_x emissions in the upstream value chain stages are due to transportation. Both metal-processing and the electricity consumption of (indirect) suppliers each cause one-fifth of NO_x emissions. One tenth is accounted for by the chemical industry. More than half of the air pollution is generated in the production of inputs, one third by direct suppliers. Air pollution at the stage of automobile manufacture and raw material production are comparatively low.

Water Consumption

The largest share of water consumption is caused by automobile manufacture at companies' own sites (just under 40%). Approximately one-fifth of the consumption is attributable to each of the levels of direct suppliers, the preceding stage, and raw material production.

The extraction of plant raw materials and metalworking processes (about one fifth each) are of importance within the industry distribution.

In the regional distribution, Germany accounts for the highest share of water consumption (just under 60%), especially at companies' own sites. Nearly 10% of the water in the entire value chain is consumed in China. In total, 15% of global water consumption is generated in regions with high water stress, particularly in the extraction of raw materials in Asia.

Land Use

Land use can primarily be accounted for by animal and plant input products (90%).

» CONCLUSION

GHG emissions are an essential environmental issue for the automotive industry. Emissions in the supply chain, i.e. from raw material production to direct suppliers, are nearly ten times higher than at companies' own sites. Measures for the reduction of GHG emissions are particularly suitable for metalworking suppliers and upstream suppliers. In addition, the reduction of electricity consumption at upstream stages can make a relevant environmental contribution.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guides from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference/*
- Environmental, Health, and Safety Guidelines of the World Bank *www.ifc.org/ehsguidelines*
- Guide from the International Council on Mining and Metals (ICMM) *www.icmm.com*
- Standards of the Aluminium Stewardship Initiative (ASI) *https://aluminium-stewardship.org*
- Self-Assessment Questionnaire on Sustainability for Automotive Sector Suppliers (SAQ) of the European Automotive Working Group on Supply Chain Sustainability *www.csreurope.org/saq-0*

Food Retailing

191 Billion EUR Turnover
1.2 M Employed

BVE – The Federation of German Food and Drink Industries (2015);
BVLH – Bundesverband des Deutschen Lebensmittelhandels (2013)

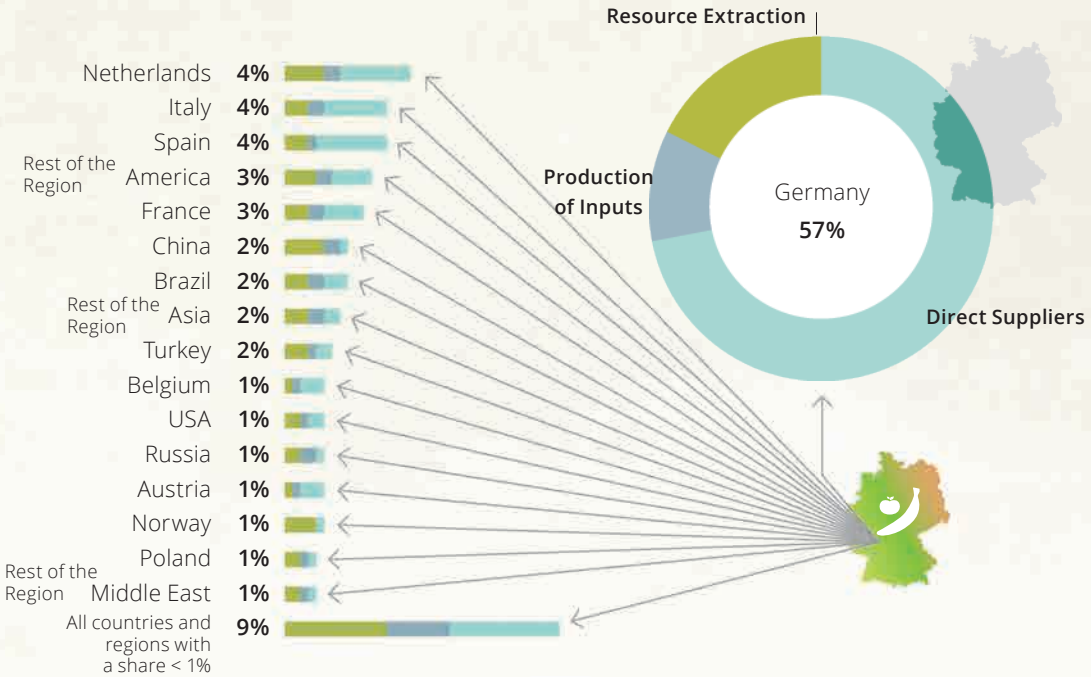
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Food Retail Companies in Germany
Fruit and Vegetables Cereals and Other Crops Oil Seeds, Sugar Cane Raw Milk Animal and Fish Feed ...	Food Processing Chemical Products ...	Plant-based Food (Primarily Fruit and Vegetables) Animal-based Food (Including Meat, Dairy and Fish Products) Processed Foods (Primarily Bread and Pastry Products, Frozen Goods, Sweets, Coffee and Tea, Beverages) ...	

The direct suppliers in food retailing can be divided into producers of plant-based, animal-based and processed foods. These are, in turn, supplied by raw material-producing or input-producing businesses, for example the chemical industry.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

A majority of the supply chain for food retailing is located within Germany (almost 60%), mainly related to processed foods. A further significant portion is distributed across the EU countries.



The Environmental Impacts of the German Food Retailing Sector along the Value Chain

Food retailers have the highest environmental impacts of all the industries under investigation. This industry is the largest water consumer. The global land use of German food retailing sector and its upstream value chain amounts to a total of 22 million hectares, which corresponds to almost two thirds of the territory of Germany.

The greatest environmental impacts are caused by raw material extraction and production. More than half of greenhouse gas and air pollutant emissions are generated by the production of raw materials. At around one-third of total emissions, the direct suppliers are also relevant. The greenhouse gas emissions of food retailers themselves are comparatively low (3%).

The share of water consumption accounted for by raw material production is as much as two-thirds. Another third is consumed by the direct suppliers. Raw material production also accounts for the majority of land use.

Distribution of Environmental Impacts along the Value Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Food Retail Companies (own sites)	Overall
Greenhouse Gases	58%	12%	27%	3%	110 Megatonnes CO_2-eq
Air Pollution	54%	9%	34%	3%	0.3 Megatonnes NO_x
Water Consumption	65%	2%	33%	0%	8,900 M m^3 Water
Land Use	79%	0%	21%	0%	22 M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.6** kg CO_2-eq
Air Pollution	**1.6** g NO_x
Water Consumption	**46.6** Litres
Land Use	**1.2** m^2

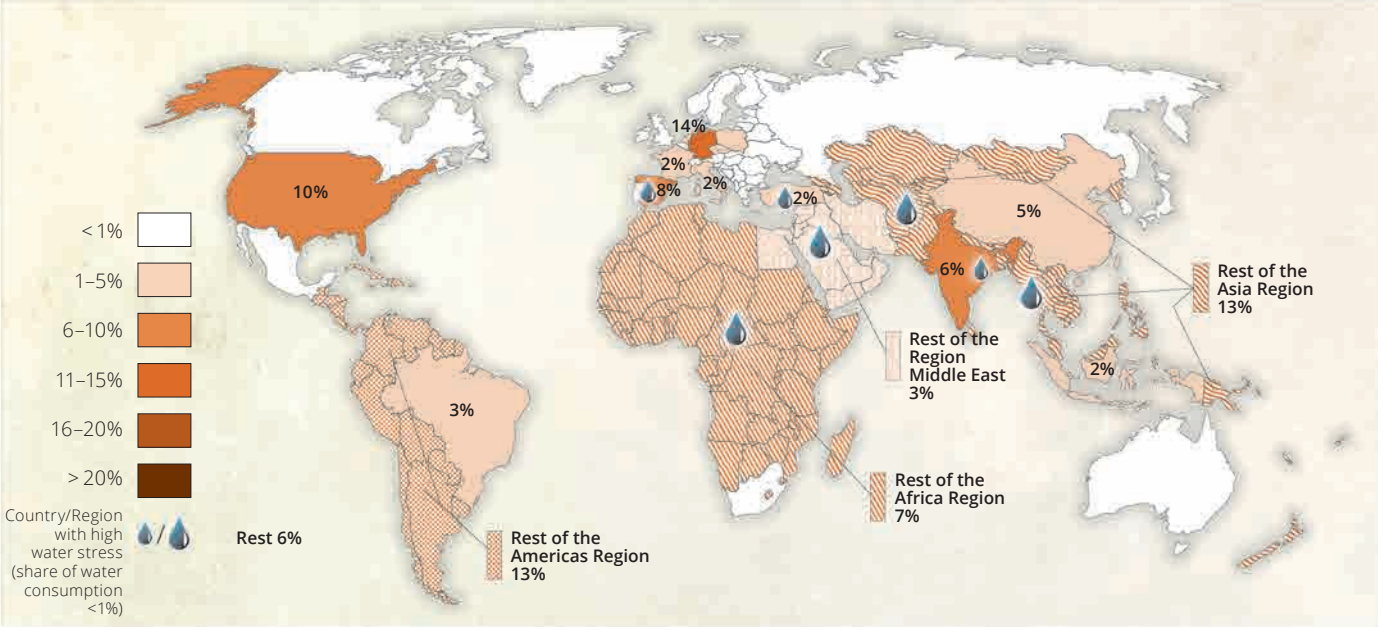
Food retailers are responsible for the highest environmental impacts per EUR turnover in almost all environmental topics. The water consumption of just under 47 litres per EUR turnover is much higher than in other industries. The environmental impacts are also significantly higher in land use than is the case in the other industries. The CO_2 emissions are comparatively high, only the metalworking industry has higher turnover-adjusted greenhouse gas emissions.

Due to its high values, water consumption along the value chain is described in detail below.

Focus:
Water Consumption

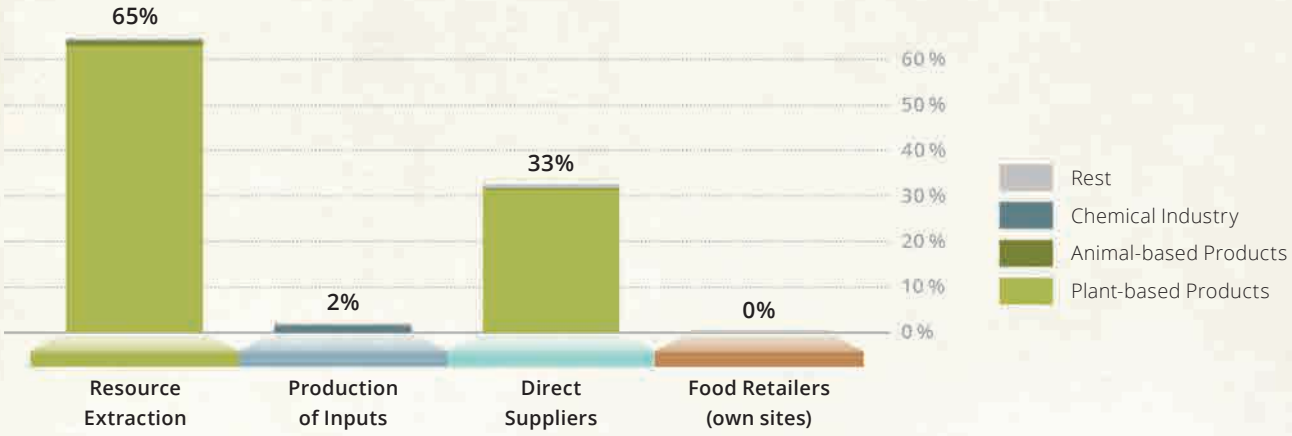
Distribution of Water Consumption in the Value Chain of the German Food Retailing Sector

By country



The highest water consumption in the value chain is found in regions with high water stress (about 40%). Spain, as an important region of origin for direct suppliers, plays an important role because the country suffers high water stress.

By industry



Water consumption in the value chain of the German food retailing sector can be traced above all to the cultivation of plants (over 90%). This applies both to the cultivation of plant-based foods and to the feed used for the production of animal-based products. The cultivation of fruits and vegetables, wheat and cereals, oil-rich seeds (rapeseed, soya etc.) and rice are especially water-intensive.

Further Environmental Impacts

Greenhouse Gas Emissions

GHG emissions are mainly caused by raw material production (about 60%) and direct suppliers (about 30%). Approximately 40% of emissions are generated by plant cultivation (e.g. fertilizer and greenhouse use) and about 30% by the production of animal-based foods (methane emissions in cattle farming). The electricity used by raw material production and the direct suppliers together amounts to about 10%.

The largest share of the GHG emissions are generated within Germany (about 40%). In addition, the Americas region, China, Asia, the USA and the Netherlands are also relevant.

Air Pollution

In terms of turnover, the main source of NO_x emissions for food retailers can be found in the value chain: these are generated mainly in raw material production and by direct suppliers. Emissions are mainly caused by the cultivation of plants. One-third of emissions are generated within Germany.

Land Use

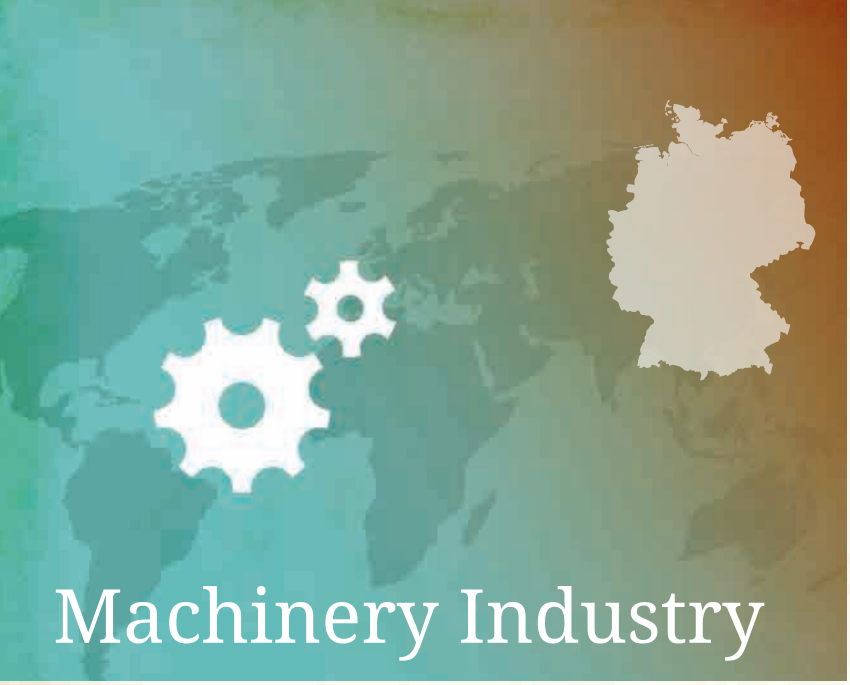
80% of the land is used for raw material production, and 20% by direct suppliers. The majority is attributable to plant cultivation and can be found in Germany and South America, in particular.

» CONCLUSION

Food retailers have the highest environmental impact when compared with the other eight industries studied. Particularly relevant is the water consumption in the production of food in regions with high water stress. This leads to areas for action emerging in relation to direct suppliers of fruit and vegetables (especially from Spain and Asia), who consume about a third of the total water consumption in the value chain. Further measures should be taken in relation to upstream suppliers in plant cultivation, for example in the cultivation of cereals, soy and rice.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Environmental, Health, and Safety Guidelines of the World Bank *www.ifc.org/ehsguidelines*
- FAO-Sustainability Assessment of Food and Agriculture Systems (SAFA) *www.fao.org/nr/sustainability/sustainability-assessments-safa/en*
- Sustainable Agriculture Standard the SAN (Sustainable Agriculture Network) *www.san.ag*
- IFOAM Norms for Organic Production and Processing *www.ifoam.bio/en/ifoam-norms*
- Info Database of the Pesticide Action Network *www.pan-germany.org/deu/~infodblist.html*
- EU Policy, Organic Farming *https://ec.europa.eu/agriculture/organic/eu-policy_en*



Machinery Industry

235 Billion EUR Turnover
1 M Employed
6,200 Companies

German Federal Statistical Agency;
Values for 2015

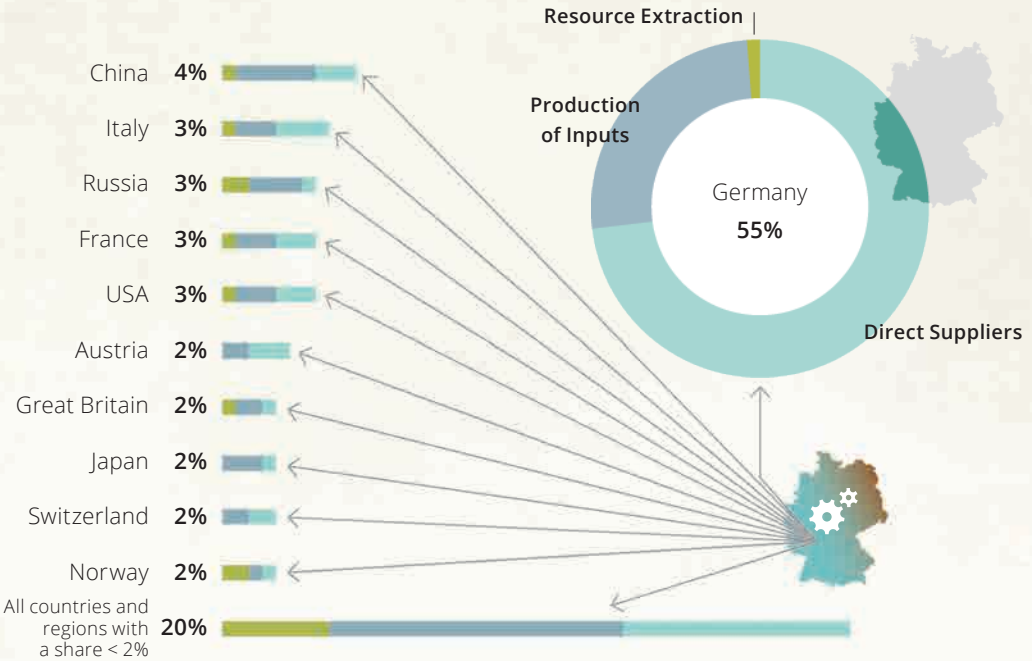
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Machinery Industry Companies in Germany
Copper Rare Earths Precious Metals Iron Ore Lead, Tin, Zinc, Nickel Aluminium ...	Metal Inputs Copper Inputs Aluminium Inputs Chemical Inputs Crude Steel Machinery Industry Plastic, Rubber ...	Metal Inputs Aluminium Inputs Electronics Machinery Industry Plastic, Rubber ...	

The machinery industry supply chain mainly comprises the metalworking industry and, in turn, machinery industry companies at upstream stages. Companies in the chemical and electronics industries also account for a high share.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

The majority of the supply chain of the German machinery industry is located in Germany. In Europe, there are many direct suppliers as well as their input suppliers. China also accounts for a significant share of the upstream stages.



The Environmental Impacts of the German Machinery Industry along the Value Chain

The machinery industry, despite its size, has relatively low environmental impacts along the value chain. Relative to turnover, it performs best among the sectors under investigation.

The environmental impacts of machinery industry are significantly higher in the supply chain than at companies' own sites. Approximately 90% of GHG and air pollutant emissions are generated in the upstream stages, with one-third of emissions attributable to direct suppliers. Most emissions are generated during the production of inputs. The supply chain accounts for more than half of the overall water consumption, with the individual stages (from raw material extraction to direct suppliers) each accounting for about a fifth. Land use is almost exclusively related to raw material production.

Distribution of Environmental Impacts along the Value Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Machinery Industry Companies (own sites)	Overall
Greenhouse Gases	9%	49%	31%	11%	60 Megatonnes CO_2-eq
Air Pollution	7%	50%	31%	11%	0.1 Megatonnes NO_x
Water Consumption	17%	21%	18%	44%	660 M m^3 Water
Land Use	89%	4%	4%	3%	1 M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.2** kg CO_2-eq
Air Pollution	**0.5** g NO_x
Water Consumption	**2.8** Litres
Land Use	**0.0** m^2

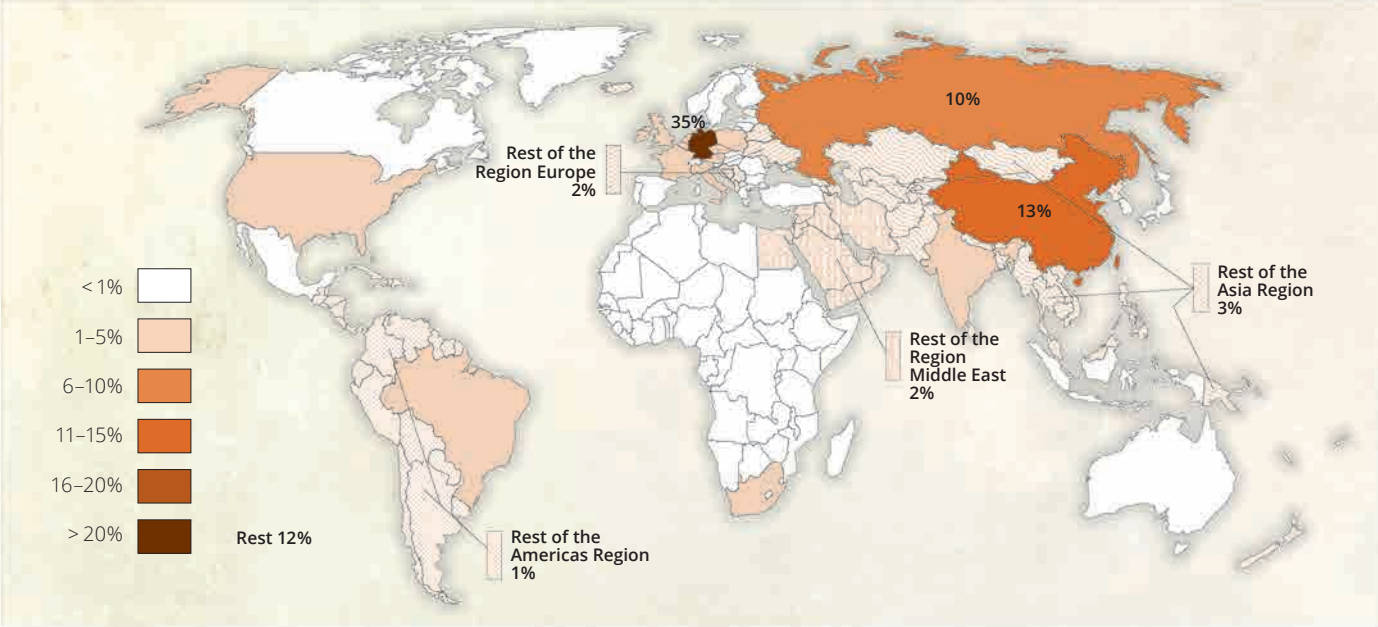
The environmental impacts of the machinery industry relative to turnover are low compared to the other industries in this study. 0.2 kg of GHG emissions are generated along the value chain per EUR of turnover. The majority occur within the supply chain. Water consumption (from raw material extraction to companies' own locations) totals 2.8 litres and is thus the lowest of the eight industries in this study. About two-fifths of water consumption takes place at the companies' own sites.

Due to its high proportion, GHG emissions along the value chain are described in detail below.

Focus:
Greenhouse Gas Emissions

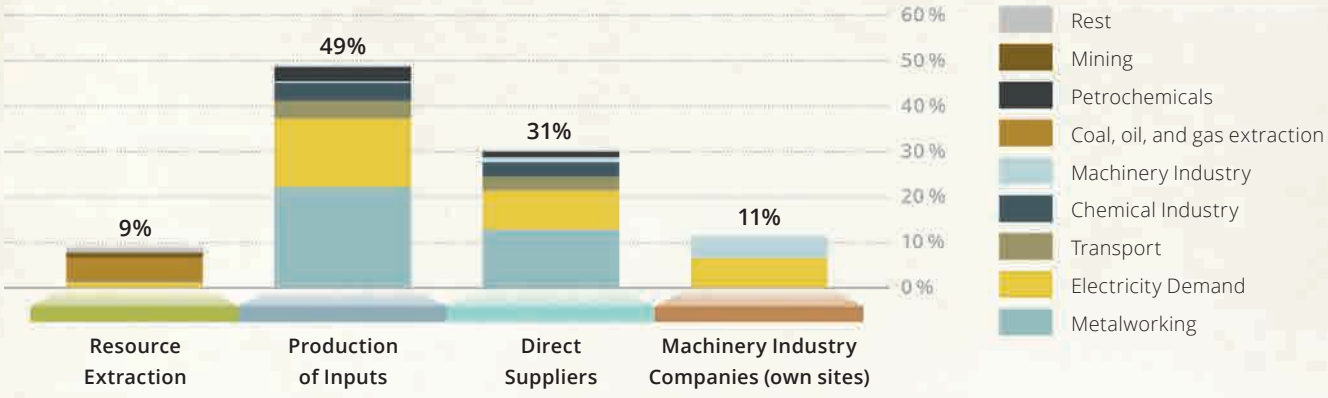
Distribution of Greenhouse Gas Emissions in the Value Chain of the German Machinery Industry

By country



Most of the GHG emissions are generated in Germany, China and Russia. In Germany, the machinery industry companies themselves are the main contributors to emissions (including via electricity use). Emissions in China and Russia can be attributed in particular to upstream metalworking plants and the electricity requirements of (indirect) suppliers.

By industry



Process emissions from metalworking account for a third of total GHG emissions in the supply chain when combining direct suppliers and their upstream stages. The emissions generated by the electricity consumption of producers along the value chain account for a further third.

Further Environmental Impacts

Air Pollution

NO_x emissions along the supply chain are distributed similarly to the GHG emissions. Almost one third of the emissions are generated by direct suppliers, and half by indirect suppliers.

In contrast to GHG emissions, however, most NO_x emissions are generated in the transport chain (one-third). In addition, a large proportion of emissions are generated by metal-processing companies, both for direct and indirect suppliers.

As in the case of GHG emissions, the supply chains leading to China have a disproportionately high share of NO_x emissions, especially in the metal-processing stages and in the electricity consumption of (indirect) suppliers.

Water Consumption

Machinery industry companies themselves consume the most water (about 40%). About one-fifth of the water consumption stems from direct suppliers, upstream stages, and resource extraction.

Metal-processing and the extraction of raw materials are prominent in the sectoral distribution (about one-fifth each).

In the regional distribution, German companies consume the most water, at about 60%. 10% of the water consumption along the value chain is to be found in China, mainly in the metal processing industry and the producers (electricity generation). About 10% of total water consumption is generated in regions with high water stress, especially in the production of raw materials in Asia and Africa.

Land Use

The highest land use (almost 90%) is accounted for by the extraction of raw materials. The main areas of land use are Africa and China.

» CONCLUSION

GHG emissions are a major environmental topic in the machinery industry supply chain. Emissions in the supply chain are many times higher than at companies' own sites – even just the emissions from the direct suppliers alone are three times as high. Here, it is worthwhile to focus on (indirect) suppliers of the metalworking industry, as well as on the electricity consumption of (indirect) suppliers. Metal processing plants also account for a high share of air pollutant emissions.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guides from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference/*
- Environmental, Health, and Safety Guidelines of the World Bank *www.ifc.org/ehsguidelines*
- Guide from the International Council on Mining and Metals (ICMM) *www.icmm.com*
- Standards of the Aluminium Stewardship Initiative (ASI) *https://aluminium-stewardship.org*

Metal Production and Processing

205 Billion EUR Turnover
910,000 Employed
8,700 Companies

German Federal Statistical Agency;
Values for 2015

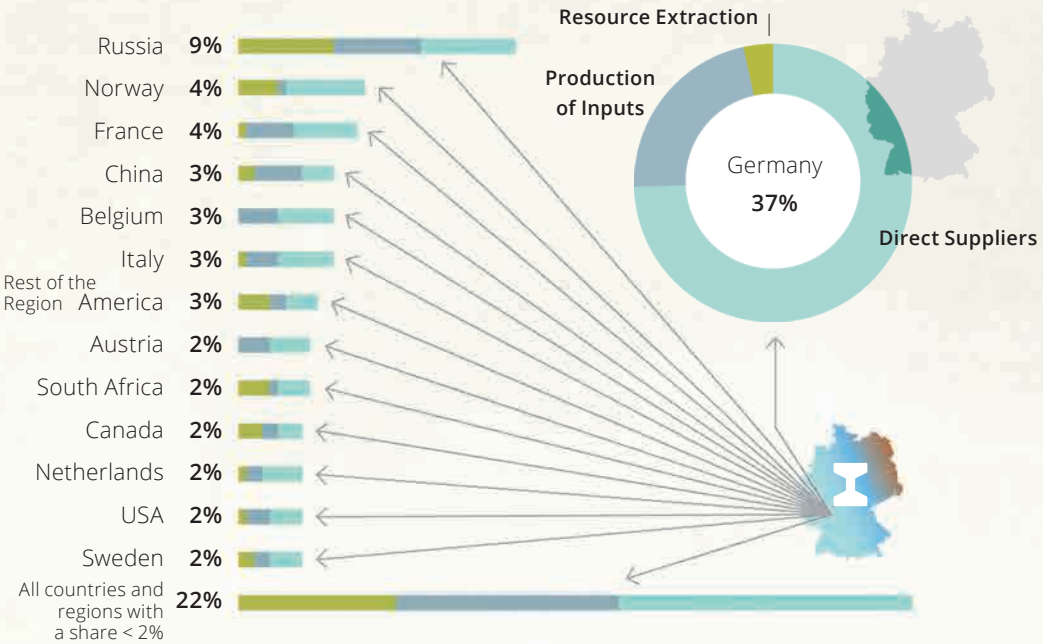
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Metal Production and Processing Companies in Germany
Crude Oil, Natural Gas, Coal Iron Precious Metals Copper Aluminium Lead, Tin, Zinc, Nickel Wood ...	Metal Inputs Precious Metal Inputs Copper Inputs Aluminium Inputs Chemical Inputs Steel ...	Metal Inputs Precious Metal Inputs Copper Inputs Aluminium Inputs Chemical Inputs Steel ...	

The value chain of the metal production and processing industry mainly comprises sectors that produce metallic inputs as well as the chemical industry and raw material-producing industries.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

The import share of the metal production and processing industry in Germany is over 60%. Important import countries are Russia, Norway and France. After Russia, numerous supply chains branch out at the stage of raw material extraction.

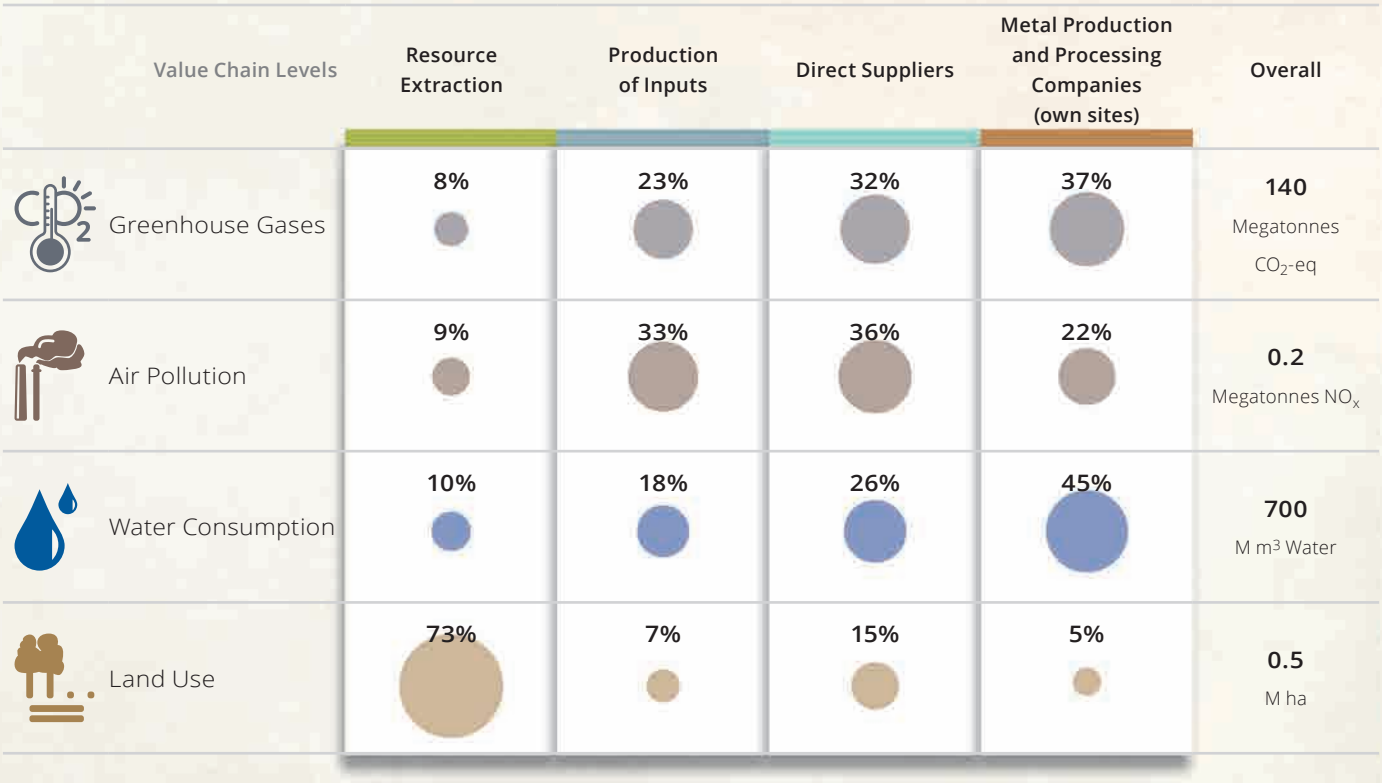


The Environmental Impacts of the German Metal Production and Processing Industry along the Value Chain

Of the eight industries included in this study, metal production and processing has the highest overall GHG emissions along the value chain. With 0.7 kilograms of CO_2-eq per EUR of turnover, it has the highest CO_2 intensity.

The environmental impacts of the metal production and processing industry are higher in the supply chain than at companies' own sites. Nearly two-thirds of the total GHG emissions and more than three quarters of the air pollutant emissions are generated in the supply chain. Direct suppliers are a major contributor to this - thus representing an important lever for the reduction of environmental impacts in companies' immediate sphere of influence. The supply chain accounts for more than half of the total consumption of water. Raw material production accounts for three-quarters of land use.

Distribution of Environmental Impacts along the Value Chain



Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.7** kg CO_2-eq
Air Pollution	**0.9** g NO_x
Water Consumption	**3.4** Litres
Land Use	**0.0** m^2

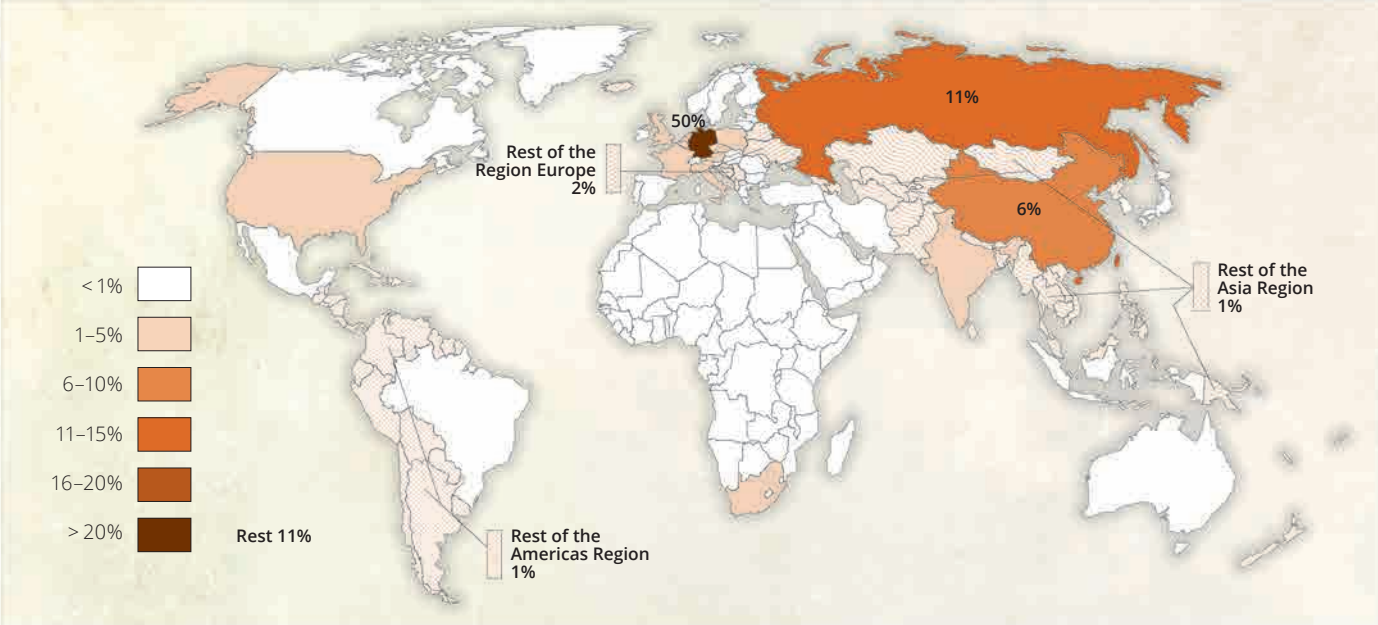
Both in absolute terms and relative to turnover, the metal production and processing industry generates the most GHG emissions among the eight industries studied. In the case of air pollutant emissions, too, it is in the upper range. Water consumption (from raw material extraction to companies' own location) totals 3.4 litres per EUR of turnover, and is therefore comparatively low.

Due to their high intensity, the GHG emissions along the value chain are described in detail below.

Focus:
Greenhouse Gas Emissions

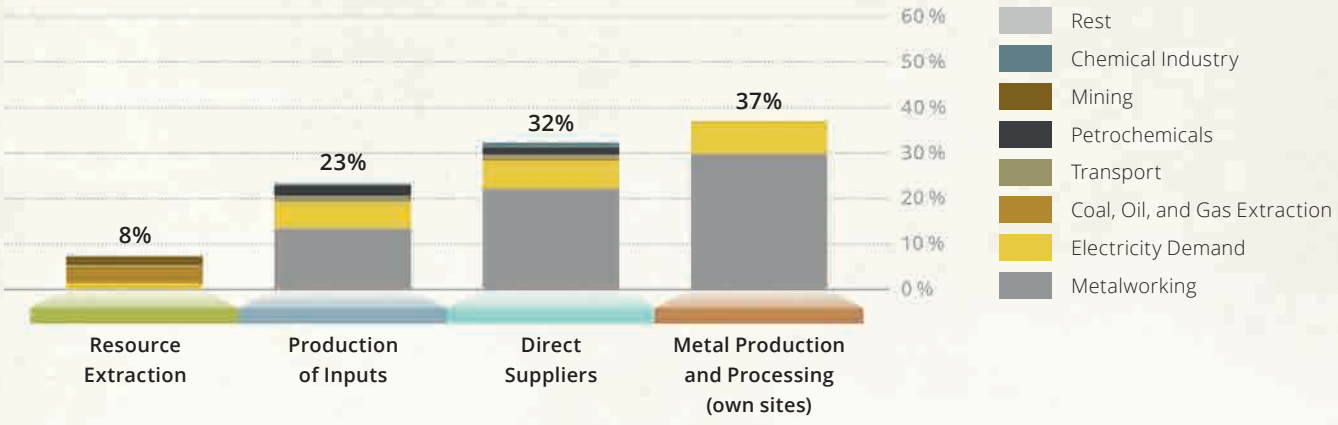
Distribution of Greenhouse Gas Emissions in the Value Chain of the German Metal Production and Processing Industry

By country



Half of the GHG emissions are generated within Germany, both at companies' own sites as well as at suppliers and indirect suppliers within Germany. More than one tenth of the total can be traced to supply chains that lead to Russia, especially for direct suppliers from the metalworking industry.

By industry



Two thirds of the GHG emissions along the value chain are generated in metal-producing and processing companies, when combining their own sites with the direct suppliers and their upstream stages. Emissions resulting from the electricity consumption of producers along the value chain amount to one-fifth.

Further Environmental Impacts

Air Pollution

The calculations of NO_x emissions along the value chain of the metal production and processing industry show that a large proportion of air pollutant emissions are generated in the metalworking industry (over 40%). Geographically, these are concentrated at their own locations in Germany, as well as on the direct suppliers. Also relevant are metal-processing producers in Russia, both direct and upstream suppliers.

NO_x emissions along the transport chain (a quarter) are also significant. One fifth is attributable to electricity use.

Water Consumption

According to the calculations, the most important share of water consumption is also attributable to the metalworking industry. A large share can be traced to the production and processing companies within, but also to the level of direct and indirect suppliers.

About 10% of total water consumption is generated in regions with high water stress, especially in the production of raw materials in Asia and Africa.

Land Use

Three quarters of the land use is attributable to raw material production, especially in Africa and Asia.

» CONCLUSION

Companies in the metal production and processing industries have high CO_2 intensity in their value chain. Therefore, reducing GHG emissions should be a priority. Corresponding activities should not be restricted to companies' own sites, but rather should also include the supply chain. Emissions in the supply chain (from raw material extraction to direct suppliers) are twice as high as at companies' own sites. For example, experiences with implementing measures to improve performance could be shared with the direct suppliers.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guides from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference/*
- Environmental, Health, and Safety Guidelines of the World Bank *www.ifc.org/ehsguidelines*
- Guides from the International Council on Mining and Metals (ICMM) *www.icmm.com*
- Standards of the Aluminium Stewardship Initiative (ASI) *https://aluminium-stewardship.org*

Paper Industry

37 Billion EUR Turnover
130,000 Employed
900 Companies

German Federal Statistical Agency;
Values for 2015

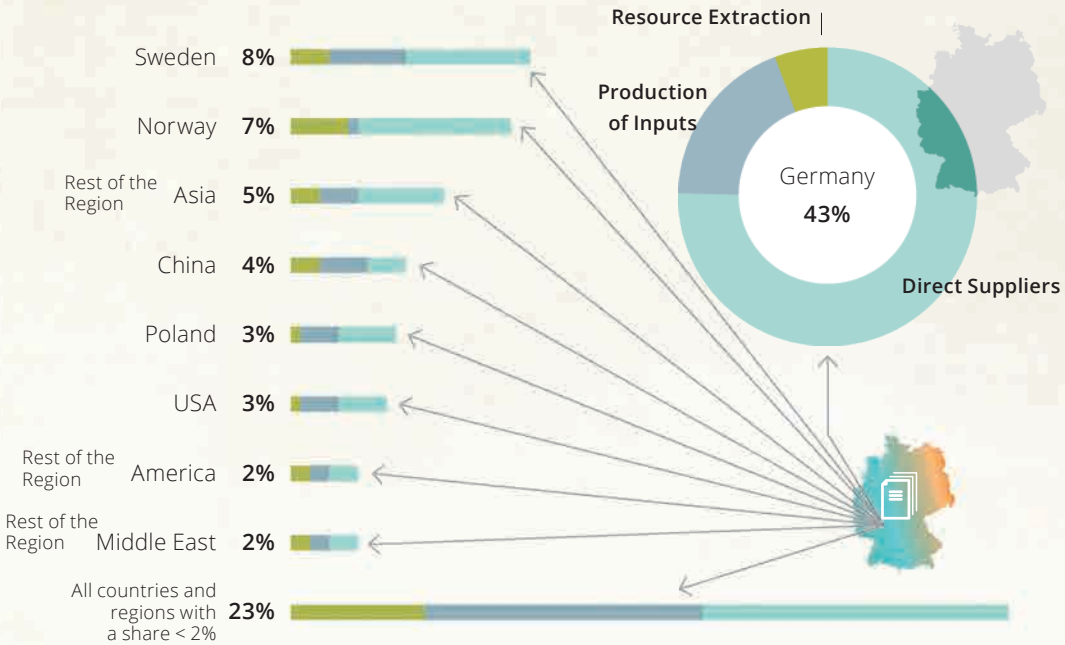
The Structure of the Value Chain

Resource Extraction	Production of Inputs	Direct Suppliers	Paper Industry Companies in Germany
Wood Crude Oil, Natural Gas, Coal Plant-based Materials ...	Wood Wood input Products Paper Chemicals Plastic Textiles ...	Wood Wood input Products Paper Chemicals Plastic Textiles ...	

The value chain of the paper industry is dominated by the wood processing industry, while the chemical industry is also a relevant industry in the supply chain.

Value Chain Components in the Supply Chain by Major Country and Supply Chain Level

More than half of the supply chain of the paper industry is outside Germany. Sweden and Norway play an important role in the supply chain, both at the direct suppliers level and at the resource extraction stage. Asia also plays an important role in the supply chain.



The Environmental Impacts of the German Paper Industry along the Value Chain

The paper industry is the smallest of the eight industries studied. Thus the absolute environmental impact along the value chain is small compared to the others, but when adjusted for turnover it is towards the top.

More than half of the GHG emissions in the value chain originate in the supply chain, mostly from the direct suppliers. A similar picture is found for NO_x emissions and water consumption. In contrast to the other sectors, a large proportion of land use is attributable to the direct suppliers, since the paper industry directly receives material from the wood and forestry sectors.

Distribution of Environmental Impacts along the Value Chain

Value Chain Levels	Resource Extraction	Production of Inputs	Direct Suppliers	Paper Industry Companies (own locations)	Overall
Greenhouse Gases	11%	19%	28%	42%	**14** Megatonnes CO_2-eq
Air Pollution	12%	24%	33%	31%	**0.04** Megatonnes NO_x
Water Consumption	25%	10%	22%	44%	**320** M m^3 Water
Land Use	24%	0%	75%	1%	**0.5** M ha

Environmental Impacts per EUR of Turnover:

Greenhouse Gases	**0.4** kg CO_2-eq
Air Pollution	**1.0** g NO_x
Water Consumption	**8.5** Litres
Land Use	**0.1** m^2

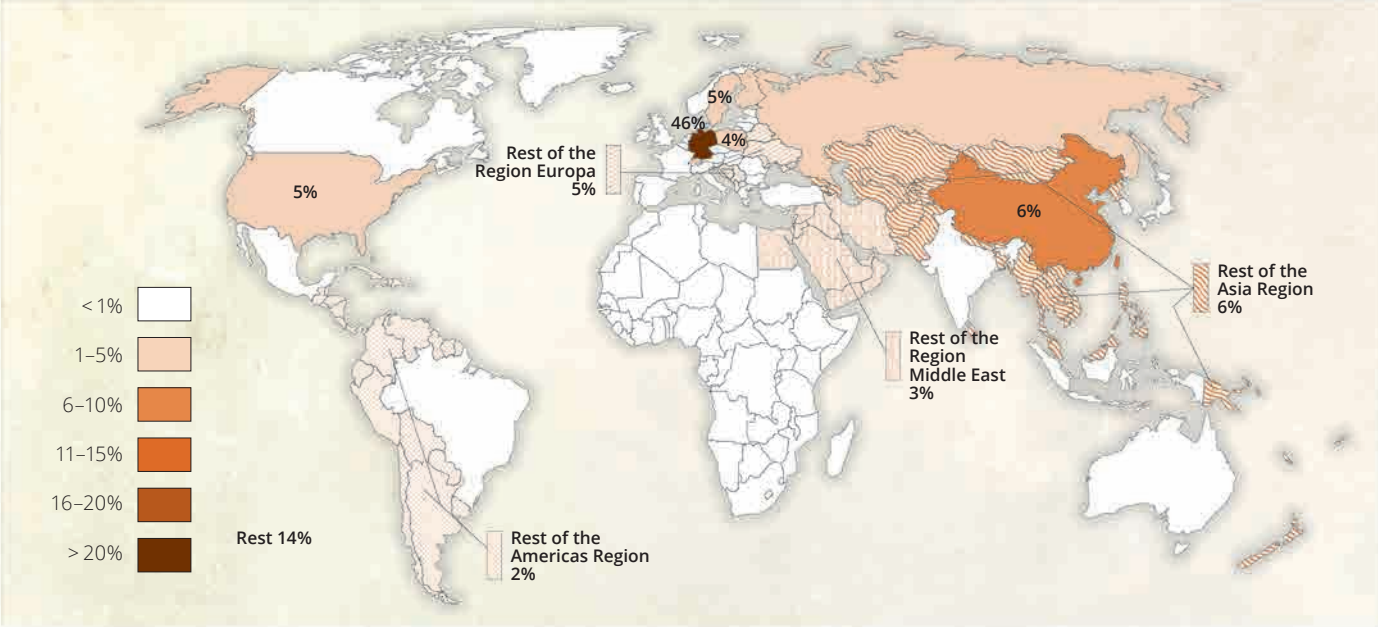
In terms of turnover, the paper industry, including its supply chain, is one of the most environmentally responsible sectors, and is one of the top four in all four environmental issues. With 0.4 kilograms of CO_2-eq per EUR turnover, it is equal to the chemical industry in terms of GHG emissions. The water consumption per EUR turnover is 8.5 litres and is therefore directly behind the food and fashion retailing sectors as well as the chemical industry. In the case of NO_x emissions, the paper industry ranks second after food retailing.

Due to the high value per EUR of turnover, the air pollution is are described in detail below.

Focus:
Air Pollution

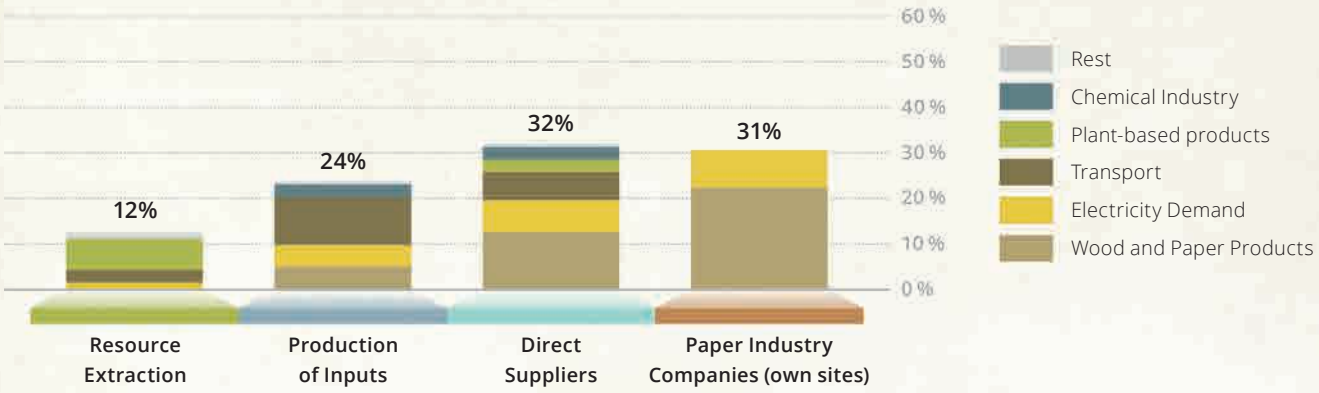
Distribution of Air Pollution in the Value Chain of the German Paper Industry

By country



The largest amount of NO_x emissions in the value chain are emitted in Germany, especially by the paper industry itself. China and Asia have a disproportionately high share in comparison with the entire value chain.

By industry



The wood and paper industry is responsible for more than 40% of the NO_x emissions along the value chain. Emissions at the level of the German paper industry and the level of direct suppliers are the highest. A further hot spot is the emissions generated by electricity use and transportation (about one-fifth each).

Further Environmental Impacts

Greenhouse Gas Emissions

Half of the GHG emissions are attributable to electricity consumption along the value chain. One quarter is attributable to direct emissions from the paper and wood industry, which are mainly concentrated on the paper industry in Germany and on the direct suppliers. The GHG emissions of the chemical industry and transport are also relevant, at almost 10%.

Approximately 60% of the GHG emissions are emitted within Germany, in particular by emissions at the companies' own sites as well as by direct suppliers. China (about 10%) has a disproportionately high share relative to its value added.

Water Consumption

The paper industry has the highest share of water consumption, both at its own locations and at suppliers from the paper industry (two-thirds). About a quarter of the consumption is generated by the production of wood.

In the regional distribution, Germany has the highest share of water consumption, especially at companies' own sites, with slightly more than half. Approximately one-fifth of global water consumption in the value chain of the paper industry is in regions with high water stress, particularly in Asia and Africa.

Land Use

Land use almost exclusively concerns the extraction of wood. The main regions are Sweden, Germany, South America and Africa.

» CONCLUSION

The paper industry has high environmental impacts per EUR of turnover. Air pollution is a key issue in the reduction of environmental impacts. One-third of this figure is attributable to the industry's own locations and to the level of direct suppliers, while another quarter is attributable to the level of the input products. A focus should be on (indirect) suppliers from the wood and paper industry and on transportation, as these sectors generate the most emissions.

» IMPORTANT STANDARDS AND SUPPORT

- EMAS Environmental Management *www.emas.eu*
- ISO 14 001ff.; ISO 50 001ff. *www.iso.org*
- Guides from the European Commission on Best Available Techniques (BAT) and Best Available Techniques Reference Documents (BREF) *http://eippcb.jrc.ec.europa.eu/reference*
- Environmental, Health, and Safety Guidelines of the World Bank *www.ifc.org/ehsguidelines*
- Forest Stewardship Council (FSC) *https://ic.fsc.org/en*
- Programme for the Endorsement of Forest Certification Schemes (PEFC) *http://pefc.org/standards/overview*

III. Possible Measures for Designing and Optimising a Sustainable Supply Chain

Once companies have gained an understanding of the environmental impact and the "hot spots" within their supply chains, it becomes important to derive appropriate measures. In principle, companies can orient themselves using the following four fields of action. The overview does not claim to be complete, but rather is intended to provide an introduction.

The industry profiles in *Part II* provide standards and support for the relevant sector and its relevant supply chains. These include both cross-sectoral and sector-specific offers. These are, on the one hand, standards or management systems, which can be proven by certificates. Implementation aids are usually available that support the fulfilment of the standards criteria and the structure of the respective management system. On the other hand, guides and important websites are mentioned in the industry profiles with support that provides companies with an overview of options for concrete measures to be taken at (indirect) suppliers.

Internal Anchoring in Supplier Management: Integration into Purchasing
Companies should include environmental protection issues in framework contracts or in a supplier Code of Conduct. For many companies, this is often the first step towards binding sustainable supply chain management. Concrete ecological requirements can be taken into account in purchasing criteria and specifications. In some industries (e.g. in the automotive industry) it is common for suppliers to have to demonstrate an Environmental Management System in accordance with EMAS or ISO 14001. Compliance can be checked by submitting certificates or auditing suppliers. At the same time, it must be ensured that the environmental criteria are actually included when selecting suppliers. This can also lead to the need to change a supplier or to specifically select suppliers that meet ecological (and in a wider sense sustainable) requirements. In the internal supplier assessment system, ecological criteria should also be taken into account, e.g. whether the supplier reports on its CO_2 emissions or has a plan of action.

External Anchoring in Supplier Management: Cooperation with Suppliers
Practical experience shows that there is a great need for knowledge transfer and capacity building among suppliers worldwide (e.g. on energy efficiency). Often the environmental performance of suppliers can be improved simply by communicating with them. The topic can be anchored, for example, in the regular target discussions with suppliers. Joint projects are also a good option for identifying appropriate solutions and improvements. In addition, communication allows for a better coordination of processes with the supplier in order, for example, to reduce transport costs. In addition, specific ex-

perience, for example from energy efficiency measures within the framework of the use of Environmental Management Systems, can be passed on to suppliers in order to effect improvements there. The qualification can be achieved by means of training programmes and through use of existing knowledge platforms. The latter provide help and information to a large number of suppliers.

Possibilities for the company to have influence can be stronger or weaker depending on the relationship to the supplier. This is why a step-by-step approach makes sense by initially involving strategic suppliers, in order to subsequently apply the experiences to a broader supplier base. Here, good practice approaches should be communicated to the suppliers and advantages (e.g. optimised processes, cost reductions) should be clearly conveyed. This reduces the inhibition thresholds for suppliers and is an important success factor for active contributions.

Supply Chain Structure: Building Sustainable Supply Chains
A further instrument is the targeted growth of transparent supply chains that meet high ecological standards. This measure covers the entire supply chain. One possibility is procurement directly from raw material producers. This creates greater transparency about the origin of materials and the existing environmental standards on the ground, which in turn enables the implementation of targeted measures to improve the environmental performance of the raw material producer.

In some industries product-related standards are widespread, such as organic agriculture in the food sector, and wood from sustainable forestry in the paper and wood sector. For many companies, the higher purchasing price is an obstacle to the procurement of products from sustainable sources. It is therefore a good idea to gradually develop sustainable supply chains and to sensitize customers to these products at the same time. With this measure, new customer groups can be opened up, but this often requires a long term approach.

Product Structure: Use of Sustainable Product Components
This field of action also covers the whole value chain. Changes to product design can be an important lever for reducing environmental impacts in the supply chain. This applies in particular to the replacement of critical raw materials with more environmentally friendly alternatives, e.g. via the use of recycled materials. Changes to product design can also help to avoid or at least reduce the scope of environmentally problematic processes. This field of action has a high potential for innovation, both for the procuring company and for the (indirect) suppliers. The prerequisites are that sustainable alternatives for product components are available and that companies are able to achieve more sustainable product design through their research and development activities.

IV. Suitable Next Steps

The “Atlas on Environmental Impacts - Supply Chains” provides companies with an overview of possible “hot spots” in their supply chains. **Since the atlas is based on general industry data, a comparison with the companies’ own supply chains is necessary.** The following five steps are intended to help companies pragmatically begin the design and optimisation of their own sustainable supply chains

1) Create transparency
Get an overview of your own suppliers and, potentially, your indirect suppliers. Compile the related goods and services by type, volume and origin. With this information, you can already determine the extent to which the results in the industry profiles apply to your company. Check whether suppliers already meet certain standards or have a certified environmental management system. Consult with your suppliers.

2) Identify suitable leverage
When significant environmental impacts and “hot spots” are identified, it is important to examine where and how to exert the most effective influence. A good starting point for your first activites are suppliers with whom you have a long-term relationship or where your company accounts for a high share of sales. Also check to what extent you can exert influence on indirect suppliers or on the extraction of raw materials, especially if they are likely to have a high impact.

3) Address environmental topics with your suppliers
Include environmental issues in future supplier negotiations. Perhaps you are not the only customer addressing environmental issues. Frequently, suppliers become active when spurred to act by several customers. Make environmental protection binding and stick to environmental requirements in supply contracts, target agreements or a supplier Code of Conduct.

4) Make use of established standards and systems
Use existing standards, systems and support. Pass this on to your suppliers. Make arrangements with the suppliers concerned to determine when the standards must be met by.

5) Define pilot projects and goals
Initiate pilot projects with selected suppliers. Both sides can gain valuable experience, which facilitates broad implementation. Define medium and long-term goals, e.g. regarding the share of suppliers with an environmental management system or for raw materials from sustainable sources. Establish a fixed process to check goal fulfilment.

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Databases used for the input-output model-based calculations

Database	Link	Description
EXIOBASE2	*www.exiobase.eu*	A global multi-regional input-output database, which represents environmentally relevant production impacts and footprints of consumer patterns.
WIOD	*www.wiod.org*	WIOD offers a series of socioeconomic variables and data on air emissions for a total of 40 countries over the period 1995-2009.


www.adelphi.de | www.systain.com