# Evonik Carbon Footprint 2018
# Evonik Industries

EVONIK
POWER TO CREATE

# Contents

EVONIK CARBON FOOTPRINT



REDUCTIONS IN GREENHOUSE GAS EMISSIONS THROUGH APPLICATION OF EVONIK PRODUCTS

# EVONIK CARBON FOOTPRINT

1

# Summary

Protecting the climate and the environment represents a major global challenge. Evonik Industries (referred to below as “Evonik”) takes climate and environmental protection extremely seriously as a key element of its corporate responsibility. The company has therefore been compiling data not only on direct greenhouse gas emissions but also on indirect greenhouse gas emissions for selected relevant categories since 2008 (see Figure 1). Allocating emissions to their various sources along the value chain is of particular importance. Analyzing the full range of emissions, from the company’s own production facilities, through various categories such as purchased energy and raw materials, transports, business travel, and production waste, to the ultimate disposal of products sold, creates a comprehensive greenhouse gas balance for the company.

The methodology for the report closely follows the Greenhouse Gas Protocol Corporate Standard (referred to below as the GHG Protocol) of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD)[1]. This standard for Scope 3 reporting by the chemical industry is further detailed in the Guidance for Accounting & Reporting Corporate GHG Emissions in the Chemical Sector Value Chain[2] (referred to below as WBCSD Scope 3 Guidance) published by WBCSD Chemicals in January 2013, in whose preparation Evonik took an active part. Unless otherwise specified, the procedural instructions defined in the WBCSD Scope 3 Chemical Sector Guidance document were taken into account for compilation of the Evonik Carbon Footprint (ECF).

The important parameter here is the carbon footprint, or $CO_2$eq footprint. The present report covers only the greenhouse gas emissions of Evonik’s continuing operations. Other potential environmental impacts, including impacts on health and safety, do not fall within the scope of the Evonik Carbon Footprint and are discussed in other publications of Evonik (such as the Sustainability Report and the environmental declarations of individual sites).

The trend in greenhouse gas emissions of Evonik, not including the use phase of Evonik products, is shown in Table 1.

Table 2 shows the greenhouse gas emissions of Evonik along the value chain by category for the year 2018. Greenhouse gas emissions from purchased energy (gross) totaled 3.9 million metric tons of $CO_2$eq; the calculation of the greenhouse gas emission balance used a balanced energy purchase figure (net, as purchase of electricity and steam less sales of electricity and steam to third parties) of 0.9 million metric tons of $CO_2$eq. The Scope 2 emissions were calculated in the past using the location-based method, using regional emission factors for the conversion. Since 2015, however, these emissions have been calculated in the Evonik Carbon Footprint in most cases by the market-based method; this approach takes account of the specific emissions of individual suppliers and market participants and therefore offers greater accuracy.

**TABLE 1:** Trend in greenhouse gas emissions along the value chain of Evonik Industries (not including the use phase)

| | *2014* | *2015* | *2016* | *2017* | *2018* |
|---|---|---|---|---|---|
| *$CO_2$eq emissions in millions of metric tons* | 25.7 | 24.7 | 25.9 | 26.9 | **27.6** |

**TABLE 2:** Greenhouse gas emissions along the value chain of Evonik Industries (not including the use phase)

| *Scope* | *Category* | *Greenhouse gas emissions in 2018 [millions of metric tons $CO_2$eq]* |
|---|---|---|
| *Scope 1* | Energy and process emissions of Evonik | 5.7 |
| *Scope 2* | Purchased energy (net: balance of purchased electricity and steam less sales of electricity and steam to third parties; market-based approach) | 0.9 |
| *Scope 3* | Category 1: Purchased chemical raw materials and packaging materials as well as indirect goods | 11.5 |
| | Category 2: Capital goods | 0.6 |
| | Category 3: Energy-related activities (outside of Scope 1 and 2) | 0.7 |
| | Category 4: Inbound transports of chemical raw materials | 0.4 |
| | Category 5: Disposal and recycling of production waste | 0.6 |
| | Category 6: Employee business travel | 0.04 |
| | Category 7: Employee commuting | 0.09 |
| | Category 8: Leased assets, upstream (company vehicles, electricity and heating of administrative buildings) | 0.03 |
| | Category 9: Outbound product transports | 0.5 |
| | Category 12: Disposal and recycling of sold products | 6.6 |
| *Total* | | **27.6** |

Differences in totals due to rounding.

[1] World Resources Institute, World Business Council for Sustainable Development:
· The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard (Revised Edition 2004),
· Required Greenhouse Gases in Inventories, Accounting and Reporting Standard Amendment (2013),
· Corporate Value Chain (Scope 3) Accounting and Reporting Standard, Supplement to the GHG Protocol Corporate Accounting and Reporting Standard (2011)
[2] World Business Council for Sustainable Development: Guidance for Accounting & Reporting Corporate GHG Emissions in the Chemical Sector Value Chain (2013) (https://www.wbcsd.org/contentwbc/download/2831/35596)

Greenhouse gas emissions rose in 2018 by 0.7 million metric tons $CO_2$eq over the previous year. Higher product-specific sales volumes in 2018 than in 2017 led to higher emissions, particularly in Category 1, Purchased chemical raw materials and packaging materials as well as indirect goods, and Category 12, Disposal and recycling of sold products. Emission factors are updated every two years and have not been updated for 2018.

The other categories show no significant deviations, in absolute terms, from the figures for the previous year. According to the specifications of WBCSD Scope 3 Chemical Sector Guidance, Category 10, Processing of sold products, is not to be included in the balance.

Due to the highly diverse application areas of Evonik products, Category 11, Use of products sold, is not included in the balance; in case of utilization by direct combustion (as for example with fuel additives), the emissions are considered in Category 12, Disposal and recycling of sold products. Emissions of Categories 13 to 15 (Leased assets, downstream; Franchises; and Investments) are not reported.

## EVONIK'S PARTICIPATION IN THE CARBON DISCLOSURE PROJECT

As a not-for-profit organization, the Carbon Disclosure Project (CDP) is currently the world's largest and most important finance sector initiative to address climate change. It is supported by more than 525 institutional investors managing total assets of US$ 96 billion. Using standardized questionnaires, the CDP annually collects data and information on the $CO_2$ emissions, climate risks, and reduction targets and strategies of companies; these data are provided voluntarily.
In 2018 Evonik received a "B" from the CDP, a slightly less good result than in the previous year when it scored an "A" for CDP Climate Change. The lower rating can be ascribed to methodological and content-related changes in the assessment approach. By way of comparison, the average grade for chemical companies participating in the CDP Climate Change survey in 2018 was a "C".

The Group's internal Life Cycle Management (LCM) team is responsible for the compilation of greenhouse gas emission data in the value chain. It uses a variety of tools such as life cycle assessments to quantify sustainability and to support business and decision-making processes. The LCM team is part of the Process Technology & Engineering Business Line in the Technology & Infrastructure Segment.

2

# Methodology

*The GHG Protocol provides the methodological framework for calculating and reporting the Evonik Carbon Footprint.*

It contains guidelines for quantifying and reporting of greenhouse gases based on the following principles:

- **relevance,**
- **completeness,**
- **consistency,**
- **transparency, and**
- **accuracy.**

Greenhouse gases are converted using specified $CO_2$ equivalence factors[3] and then totaled as $CO_2$ equivalents ($CO_2$eq).

The WBCSD Scope 3 Chemical Sector Guidance published in January 2013 describes standard procedures for implementing the requirements of the GHG Protocol for Scope 3 reporting of the chemical industry.

## 2.1 ORGANIZATIONAL BOUNDARIES

The Evonik Carbon Footprint was calculated for the continued activities of Evonik in accordance with the full consolidation approach, which was chosen to match the financial and environmental reporting of Evonik. Evonik is aware of the fact that this approach can lead to double-counting of greenhouse gas emissions in cases when two or more external companies holding shares of the same legal entity report their emissions. Emissions arising from discontinued activities are not reported.

## 2.2 OPERATIONAL BOUNDARIES

The calculation of the Evonik Carbon Footprint is based on the principles of the GHG Protocol, following the scope concept of operational boundaries[4] (Figure 1).

Scope 1 covers direct energy- and process-related emissions of Evonik, while indirect emissions from purchased electricity and thermal energy for company use are combined in Scope 2, and those from other emission sources in Scope 3.

For the recording and management of Scope 1 emissions from production processes and Scope 2 emissions from secondary energy purchase, along with over one hundred other environmentally relevant reporting items, Evonik uses the Sustainability Reporting (SuRe) system. This brings together all information associated with Environment, Safety, Health, and Quality (ESHQ) reporting that is required for the regulatory authorities or is relevant to sustainability.

Evonik's Scope 3 data include emissions from the following categories:

- Category 1: Purchased chemical raw materials and packaging materials as well as indirect goods
- Category 2: Capital goods
- Category 3: Energy-related activities (outside of Scopes 1 and 2)
- Category 4: Inbound transports of chemical raw materials
- Category 5: Disposal and recycling of production waste
- Category 6: Employee business travel
- Category 7: Employee commuting
- Category 8: Leased assets, upstream (company vehicles, electricity and heating of administrative buildings)
- Category 9: Outbound product transports
- Category 12: Disposal and recycling of sold products

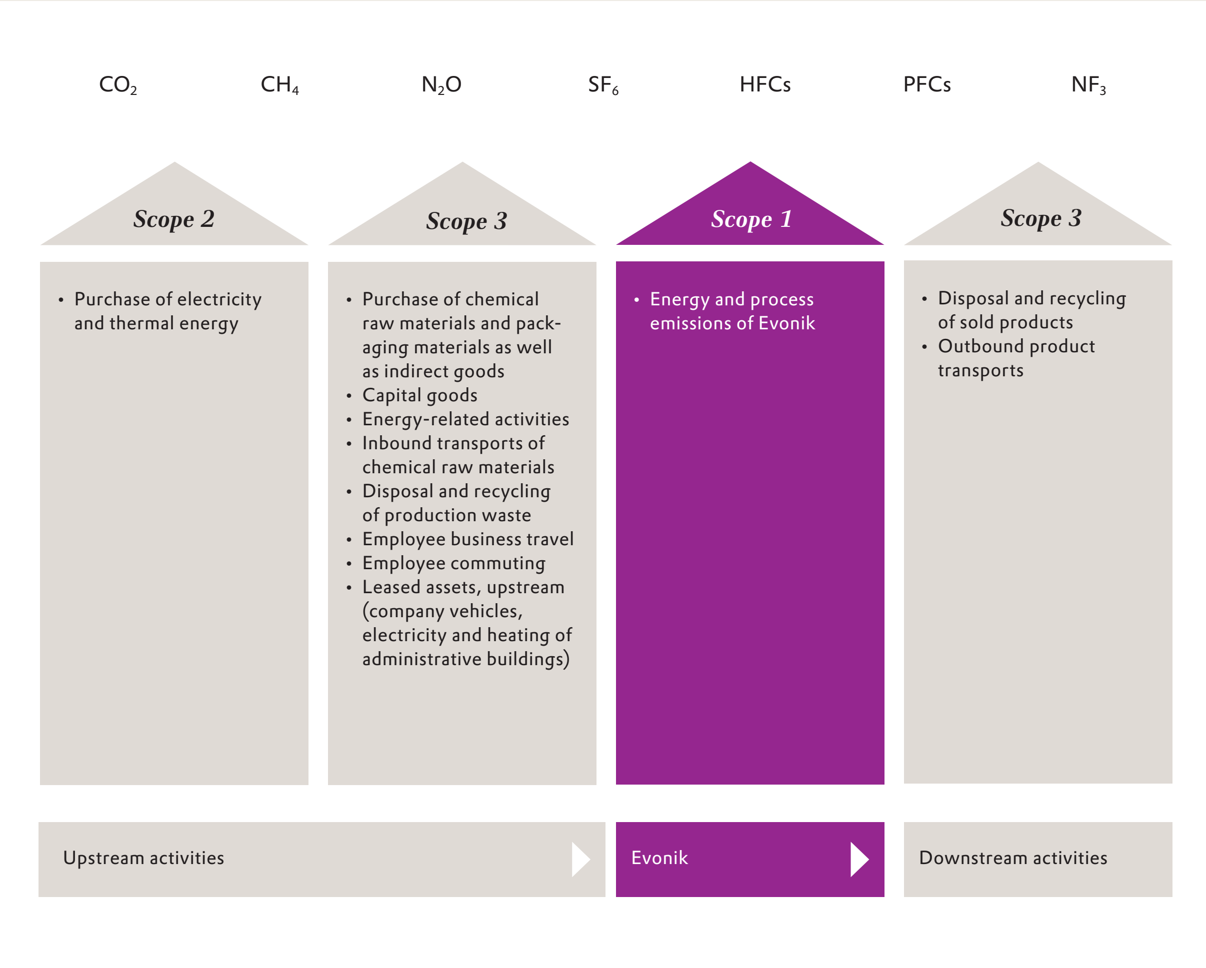
In accordance with the specifications of WBCSD Scope 3 Chemical Sector Guidance, Category 10 (Processing of sold products) is not included in the balance. Due to the large number of products sold by Evonik, Category 11, (Use of sold products) is not included in the balance; in case of utilization by direct combustion (such as for fuel additives), the emissions are considered in Category 12 (Disposal of sold products). Emissions of Categories 13 to 15 (Leased assets downstream, Franchises, and Investments) are not reported.

The calculations for greenhouse gas emissions described below do not include the setting up of infrastructure, such as roadbuilding or IT infrastructure.

The following specific calculation approaches, based partly on estimates and assumptions, were used to determine greenhouse gas emissions within the different scopes:

[3] Intergovernmental Panel on Climate Change (IPCC): Fifth Assessment Report (AR5): Climate Change 2013 – The Physical Science Basis, Chapter 8, Table 8.A.1
[4] See GHG Protocol (http://www.ghgprotocol.org) for further details on the definition of principles and scopes

**FIGURE 1:** Overview of areas covered for reporting of greenhouse gas emissions along the value chain




**CATEGORY 1:**
### *PURCHASED CHEMICAL RAW MATERIALS AND PACKAGING MATERIALS AS WELL AS INDIRECT GOODS*

In accordance with the WBCSD Scope 3 Chemical Sector Guidance, the emissions from extraction, production, and transports (except for the transports to Evonik reported in Category 4) of chemical raw materials and packaging materials, and from indirect goods were calculated in this category. Contrary to WBCSD Scope 3 Chemical Sector Guidance, the calculation does not include emissions from services purchased.

***Chemical raw materials***
The calculation of the carbon footprint was based on a listing of all purchased chemical raw materials provided by Evonik Procurement, referencing the 100 most frequently purchased raw materials by volume. An extrapolation of greenhouse gas emissions was performed on the basis of raw material volumes. The 100 raw materials considered represent a significantly higher coverage of the total volume purchased than the 80 percent coverage mandated by the WBCSD Scope 3 Chemical Sector Guidance.

thinkstep AG then helped identify the current emission factors for the raw materials from the GaBi 7 database (2017 version); these were used to calculate the carbon footprint taking into account the volumes purchased. Emission factors were determined using geographically representative factors where available. In other cases, average values for multiple countries (e.g., global, EU) were used if possible, with individual country-specific data sets being used only as a last resort. The purpose of this approach was to minimize possible uncertainties in relation to regional differences in production processes and energy generation. For substances whose emission factors could not be determined, thinkstep AG estimated an emission factor based on similar products or applied an appropriate mean emission factor.

***Indirect purchased goods and packaging materials***
Emissions from the production of indirect goods and packaging have been reported since 2014. However, this category does not include emissions from purchased services. The calculation of emissions for the production of purchased goods, except for chemical raw materials, is based on a categorized compilation of procurement volumes of indirect purchases and packaging materials. This data includes purchases of both consumable and capital goods. Evonik Procurement was responsible for allocation of the individual categories to the reporting categories 1 (raw materials purchased) and 2 (capital goods).

Analogously to the evaluation of chemical raw materials, the top 100 categories were analyzed by purchase volume. An extrapolation of greenhouse gas emissions was performed on the basis of procurement volumes. The 100 categories considered satisfy the requirement of a coverage of at least 80 percent of total purchase volume, as mandated by the WBCSD Scope 3 Chemical Sector Guidance.

The purchased material volumes were calculated based on purchase values, using average prices. For these materials, current emission factors were then identified from the GaBi 7 database (2017 version) to calculate emissions from the production of indirect goods.

**CATEGORY 2:**
### *CAPITAL GOODS*

The emissions calculation for capital goods is also based on the data for indirect purchasing. The purchase categories were divided into purchase of capital goods and of additional indirect goods. Emissions for the latter are reported in Category 1, while those for capital goods are reported in Category 2.

The top 100 categories were again analyzed by purchase volume. An extrapolation of greenhouse gas emissions was performed on the basis of purchase volumes. The 100 categories considered represent a coverage of at least 80 percent of total purchase volume, as mandated by the WBCSD Scope 3 Chemical Sector Guidance. As suggested in the Guidance, a breakdown into various materials was carried out for each purchase category.

The quantities contained in the purchase volumes were determined using average prices for these materials. Current material-specific emission factors were then identified from the GaBi 7 database (2017 version) to calculate emissions from the production of capital goods.

**CATEGORY 3:**
*ENERGY-RELATED ACTIVITIES (OUTSIDE OF SCOPE 1 & 2)*

Category 3 reports emissions from the production of solid, liquid, and gaseous energy sources that are used in the power plants operated by Evonik. These are not taken into account in Scopes 1 & 2. The calculation is based on the energy volumes produced as recorded in the SuRe system. For determination of greenhouse gas emissions for the production of solid, liquid, and gaseous energy sources, the emission factors used were from the GaBi 7 database (2017 version).

**CATEGORY 4:**
*INBOUND TRANSPORTS OF CHEMICAL RAW MATERIALS*

Because Evonik does not have complete information about transport distances and modes of transport for inbound raw materials, a mean emission factor per metric ton of transported product was calculated for outbound transports and used to calculate emissions for inbound goods transports. This mean emission factor represents a mean of the various transport modes and distances of Evonik's outbound product transports. The use of this mean emission factor is based on the assumption that the mean transport modes and distances are applicable to both inbound and outbound transports of Evonik. The emission factors for the various transport modes were taken from the European Chemical Industry Council (CEFIC).[5] Since these emission factors do not take into account the provision of fuels, a supplement was added for this. Transport emissions were determined for the extrapolated raw material volumes (cf. Category 1).

**CATEGORY 5:**
*DISPOSAL AND RECYCLING OF PRODUCTION WASTE*

The emissions from disposal of production waste were calculated on the basis of the SuRe system data on the waste volumes for each type of disposal. Emission factors for the specific disposal types were selected in a similar way to those for the end-of-life calculation in Category 12. The WBCSD Scope 3 Chemical Sector Guidance specifies that thermally recovered waste is to be included in the balance in Scope 1. For example, the Marl site uses energy from its special waste incineration plant. Since the data does not permit a separation of waste processed within and outside Evonik, all emissions are included in the balance in Category 5, in contradiction to the WBCSD Scope 3 Chemical Sector Guidance. The calculation also factors in emissions from the disposal of building and demolition rubble.

**CATEGORY 6:**
*EMPLOYEE BUSINESS TRAVEL*

The $CO_2$eq emissions caused by business travel were calculated from travel distances provided by Evonik Travel Management, on the basis of the corresponding emission factors of the transport media used. The calculation of greenhouse gas emissions was performed for employees in Germany and extrapolated to the global workforce.

[5] McKinnon, Prof. Alan; Piecyk, Dr. Maja: "Measuring and Managing $CO_2$ Emissions of European Chemical Transport", Logistics Research Centre, Heriot-Watt University, EDINBURGH, UK, 2011



**CATEGORY 7:**
*EMPLOYEE COMMUTING*

The emissions caused by commuting to and from work were conservatively estimated in accordance with the assumptions from the WBCSD Scope 3 Chemical Sector Guidance: All Evonik employees use a private vehicle to commute an estimated distance of 30 km one way (60 km round-trip per day) on 220 workdays. The emission factor per person-kilometer was based on the data of BEIS[6], in accordance with the WBCSD Scope 3 Chemical Sector Guidance.

**CATEGORY 8:**
*LEASED ASSETS, UPSTREAM*

COMPANY CARS (EXCLUDING UTILITY VEHICLES)
The $CO_2$eq emissions of Evonik company cars were calculated using data on the average distance travelled, the total number of company cars, manufacturer data on $CO_2$eq emissions, and additional allowances for car manufacturing and the provision of fuel. This calculation was performed for employees in Germany and extrapolated over the global workforce.

ELECTRICITY AND HEATING REQUIREMENTS OF ADMINISTRATIVE BUILDINGS
Provided that a production plant subject to regulatory $CO_2$eq reporting requirements exists at the site, $CO_2$eq emissions from electricity and heating of administrative buildings are already included in the SuRe system and therefore in Scope 1 and Scope 2 emissions. At purely administrative sites, greenhouse gas emissions were determined based on average electricity and heating needs per employee, compiled at a few major administrative sites. The total $CO_2$eq emissions for this category were calculated from the employee numbers at the administrative sites.

**CATEGORY 9:**
*OUTBOUND PRODUCT TRANSPORTS*

The $CO_2$eq emissions of outbound transports of chemical products were calculated using CEFIC emission factors as recommended in the WBCSD Scope 3 Chemical Sector Guidance. The calculations are based on outbound volumes, average transport distances, and the selected means of transport, as provided by logistics procurement.

[6] Department for Business, Energy & Industrial Strategy,
https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017

**CATEGORY 12:**
*DISPOSAL AND RECYCLING OF SOLD PRODUCTS*

The emissions caused by the disposal of Evonik products were calculated by the steps outlined below. Since Evonik does not always know the final application of its products—particularly in the case of intermediates—end-of-life emissions were calculated not for the applications per se, but only for the Evonik products involved. This means that end-of-life emissions were calculated only for the product volume sold by Evonik, and not for the end products produced from them using third-party raw materials. $CO_2$eq emissions were calculated, using emission factors, for the following disposal methods:

- recycling,
- sealed and open landfills, and
- incineration with and without energy recovery.

For each disposal method, the average percentage of that disposal method was determined on each continent, and all products sold by Evonik on that continent in the year 2017 were weighted by these percentages.

$CO_2$eq emissions for disposal were calculated from the sales volumes of each product line and the corresponding emission factors. For product lines whose products are clearly not treated by the usual disposal methods, specific calculations have been performed following the recommendations of the WBCSD Scope 3 Chemical Sector Guidance; for example, emissions from the incineration of products have been determined on the basis of stoichiometric ratios, and those from inert products calculated using a separate analysis.

# 3

# Results

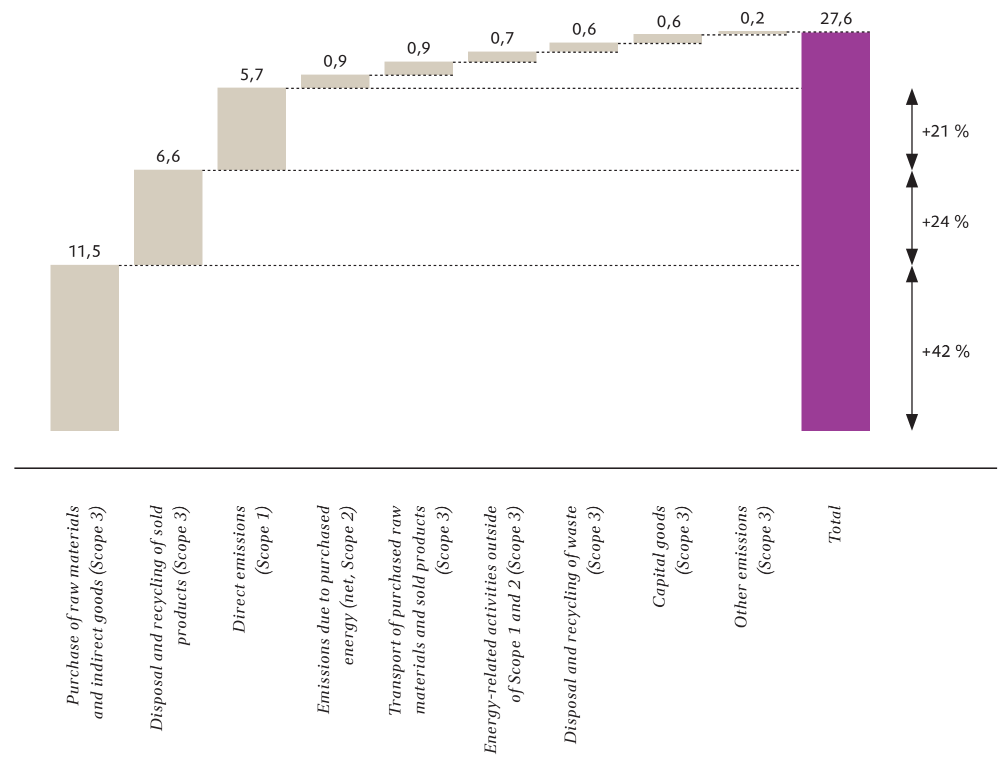
The total $CO_2$eq emissions of Evonik along the value chain amounted to 27.6 million metric tons of $CO_2$eq in 2018 (see Table 3). The highest share of emissions is from the procurement of chemical raw materials and packaging materials as well as from indirect goods, followed by emissions from disposal in Scope 3 and direct emissions in Scope 1.

Table 4 shows the trends in the individual categories from 2014 to 2018. As a consequence of the regular updating of emission factors, emissions for purchased raw materials showed a drop in 2015 as compared with 2014, despite slightly increased volumes. The $CO_2$eq emissions from disposal of production waste as well as from products sold also decreased due to updated emission factors. However, greenhouse gas emissions increased in 2016 by 1.2 m metric tons $CO_2$eq over the previous year. This is largely due to higher sales volumes for products sold and the associated increase in raw material purchases. As a result, greenhouse gas emissions are seen to have increased, particularly in Purchase of Raw Materials (category 1) and End-of-life Treatment of Sold Products (category 12). The year 2017 saw a further increase in sales volume; this is reflected in an increase in emissions in category 1. On the other hand, emissions in category 12 were marginally lower due to a small shift in product-specific sales volumes. An increase in sales volume was observed also in 2018, but not equally for all products. The product-specific increase in sales leads in particular to an increase of $CO_2$eq emissions in Purchase of Raw Materials (category 1); the other categories are affected only to a small extent.

**TABLE 3:** Trend in greenhouse gas emissions along the value chain of Evonik Industries (not including the use phase)

| | *2014* | *2015* | *2016* | *2017* | *2018* |
|---|---|---|---|---|---|
| *$CO_2$eq emissions in millions of metric tons* | 25.7 | 24.7 | 25.9 | 26.9 | **27.6** |

**FIGURE 2:** Evonik Carbon Footprint 2018 [in millions of metric tons $CO_2$eq]




Differences in totals due to rounding.

**TABLE 4:** Trends in greenhouse gas emissions in the individual categories along the value chain of Evonik Industries (not including the use phase)

| *In millions of metric tons $CO_2eq$* | *2014* | *2015* | *2016* | *2017* | *2018* |
|---|---|---|---|---|---|
| *Production facilities of Evonik (Scope 1)* | 5.9 | 5.6 | 5.4 | 5.6 | **5,7** |
| *Purchased energy (net, balance of purchased electricity and steam less sales of electricity and steam to third parties) (Scope 2)* | 1.0 | 1.0 | 1.0 | 0.9 | **0,9** |
| *Category 1: Purchased chemical raw materials and packaging materials as well as indirect goods (only purchase of chemical raw materials until the end of 2013) (Scope 3)* | 9.5 | 9.3 | 10.3 | 11.1 | **11,5** |
| *Category 2: Capital goods (Scope 3)* | 0.6 | 0.5 | 0.6 | 0.5 | **0,6** |
| *Category 3: Energy-related activities (outside of Scope 1 & 2) (Scope 3)* | 0.7 | 0.7 | 0.6 | 0.6 | **0,7** |
| *Category 4: Inbound transports of chemical raw materials (Scope 3)* | 0.3 | 0.4 | 0.4 | 0.4 | **0,4** |
| *Category 5: Disposal and recycling of waste generated in operations (Scope 3)* | 0.5 | 0.4 | 0.5 | 0.5 | **0,6** |
| *Category 6: Employee business travel (Scope 3)* | 0.03 | 0.04 | 0.04 | 0.04 | **0,04** |
| *Category 7: Employee commuting (Scope 3)* | 0.1 | 0.1 | 0.1 | 0.1 | **0,09** |
| *Category 8: Leased assets, upstream (company vehicles, electricity and heating of administrative buildings) (Scope 3)* | 0.02 | 0.02 | 0.02 | 0.03 | **0,03** |
| *Category 9: Outbound product transports (Scope 3)* | 0.5 | 0.5 | 0.4 | 0.5 | **0,5** |
| *Category 12: Disposal and recycling of sold products (Scope 3)* | 6.6 | 6.2 | 6.6 | 6.5 | **6,6** |
| **TOTAL** | **25.7** | **24.7** | **25.9** | **26.9** | **27,6** |

Differences in totals due to rounding.


REDUCTIONS
IN GREENHOUSE
GAS EMISSIONS
BY THE USE
OF EVONIK
PRODUCTS

1

# Summary

Evonik offers numerous products that—compared with conventional alternatives—make a positive contribution to reducing greenhouse gas emissions in their applications. This section presents certain selected "beacon" products that, compared with their established alternatives, save the greenhouse gas emissions shown in Table 5.

The reductions listed here are generated by the applications of the following four products: "green tire" technology, amino acids in animal feed, foam stabilizers for insulation materials, and oil additives in hydraulic oils. Savings were generated over the life cycle of the applications that were manufactured with the product volumes sold by Evonik in the specified year.

Unless otherwise specified, the data has been compiled since 2013 using the methodology recommended for reporting avoided emissions in the guidance published by the World Business Council for Sustainable Development (WBCSD) in October 2013 (hereinafter "WBCSD Avoided Emissions Guidance"). In 2017 the guidelines were updated and a second edition published[7]. The WBCSD Avoided Emissions Guidance was developed with the participation of a number of globally active chemical corporations and represents a first international, multi-company agreement on the recording of avoided greenhouse gas emissions of products and their applications. Evonik was also an active participant in the development of the WBCSD Avoided Emissions Guidance.

The criteria for including beacon products in the portfolio of emission-saving products of Evonik closely follow the criteria listed in the WBCSD Avoided Emissions Guidance for selecting a reference product. Both the emission-saving product and the reference product must deliver the same function to the user and be used in the same application. Additionally, the reference solution must be available on the market, interchangeable for the typical customer on the selected market, and as similar as possible to the emission-saving product in terms of data quality, methodology, and assumptions.

The WBCSD Avoided Emissions Guidance recommends reporting the calculated savings associated with the selected application in its entire value chain. Table 5 reports the total savings of selected applications in which Evonik products are used. The contributions of

[7] World Business Council for Sustainable Development, Avoiding Greenhouse Gas Emissions: Accounting for and Reporting Greenhouse Gas (GHG) Emissions Avoided along the Value Chain based on Comparative Studies, 2017



**TABLE 5:** Trend in greenhouse gas savings over the life cycle of applications of the Evonik products sold in the specified year

| | *2014* | *2015* | *2016* | *2017* | *2018* |
|---|---|---|---|---|---|
| *$CO_2$eq savings in millions of metric tons* | 92.5 | 92.2 | 95.2 | 101.8 | **108,0** |

the individual products are described in qualitative terms (see Appendix), using the significance categories listed in Table 6.

Greenhouse gas emissions saved in 2015 did not differ much from those in 2014, in spite of increased production volume for individual emission-saving products. This is essentially due to a recalculation of savings for green tires. The associated life cycle assessment was updated in 2015. The increase in saved greenhouse gases from 2015 to 2016 is ascribed to a higher sales volume for green tire technology as well as further regionalization of sales volume for foam stabilizers for insulation materials. These effects offset the decrease in saved greenhouse gases due to the absence of the beacon product of specialty oxides in compact fluorescent lamps; these were included in the calculation before 2016 but are not considered from 2016 onward due to the decline in sales volumes. The increase in avoided emissions from 2016 to 2017 is due to increased sales volumes for all four of the emission-saving products. The year 2018 saw a further increase of avoided emissions achieved through the use of Evonik products. This increase is due to increased sales volumes for three of the four products evaluated.

These $CO_2$eq savings are not directly comparable with the Evonik Carbon Footprint, because that refers to emissions associated with the manufacture of Evonik products (generally intermediates) and includes both production and supply chain emissions as well as emissions arising from disposal, excluding the use phase. By contrast, the $CO_2$eq savings have been calculated on the basis of the life cycle emissions of applications of selected Evonik products.

Evonik's internal Life Cycle Management (LCM) team is responsible for the compilation of greenhouse gas emission data in the value chain. It uses a variety of tools such as life cycle assessments to quantify sustainability and to support business and decision-making processes. The LCM team is part of the Process Technology & Engineering business line in the Technology & Infrastructure segment.

2

# Methodology

Life cycle emissions are typically calculated in Life Cycle Assessments (LCAs) in accordance with DIN ISO 14040 ff. The WBCSD Avoided Emissions Guidance specifies that comparative LCAs should be used to calculate reductions in greenhouse gas emission. However, because LCAs are very time- and resource-intensive, they are not generated for all Evonik products. If, therefore, no LCA is available for the application of a beacon product, emissions and reductions are calculated using the externally tested Carbon Footprint Estimation (CFE) method, primarily on the basis of emission factors from the GaBi[8] LCA software used by Evonik.

Evonik developed the CFE model as a method for evaluating early project and research ideas in terms of their greenhouse effects as well as for calculating $CO_2$eq emissions and savings of products or processes. The methodology of a CFE resembles that of an LCA with some simplifications. In contrast to a full LCA, however, the CFE focuses only on the greenhouse effects of products and processes. More detailed information about the CFE model can be found in the Evonik brochure "Carbon Footprint Estimation – A model for the evaluation of potential climate impacts of new products in the research stage."

The Simplified Calculation Methodology mentioned in the WBCSD Avoided Emissions Guidance was used for the savings calculation based on comparative LCAs as well as for comparisons based on CFEs. This simplified method specifies that identical parts in the reference and Evonik solutions be excluded from consideration because they do not affect the calculation of saved greenhouse gas emissions. To give an example, the calculation of avoided greenhouse gas emissions for green tire technology did not take account of the entire vehicle over its value chain, but considered only the savings from the use of the silica-silane reinforcement system and synthetic rubber (styrene butadiene and polybutadiene rubber) in a car tire over 150,000 km. This approach has no impact on the ultimate amount of the calculated greenhouse gas reductions. The section below gives further details of the calculation method in the context of the respective reduction projects.

Figure 3 shows an illustration of greenhouse gas emissions and reductions for the reference and Evonik solutions, based on the WBCSD Avoided Emissions Guidance.

**GREENHOUSE GAS REDUCTIONS ARE CALCULATED IN ACCORDANCE WITH THE WBCSD AVOIDED EMISSIONS GUIDANCE FOR THE FOLLOWING COMPARATIVE CATEGORIES:**

- Category 1, in which the reference solution is equivalent to non-use of a product
- Category 2, in which the reference solution originates from another sector of industry
- Category 3, in which the reference solution also originates from the chemical industry

**FIGURE 3:** Illustration of $CO_2$eq emissions and reductions for the reference and Evonik solutions (based on the WBCSD Avoided Emissions Guidance, p. 9)

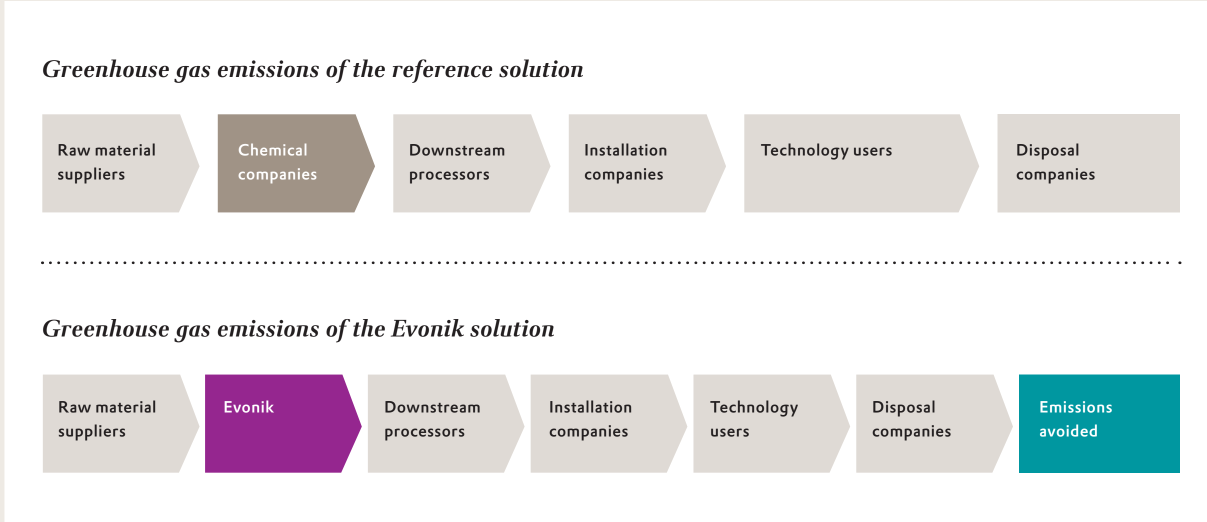



**TABLE 6:** Significance of the contribution of a chemical product to saving emissions in the value chain, based on its functioning (source: ICCA, WBCSD, Avoiding Greenhouse Gas Emissions– The Essential Role of Chemicals, p. 25).

| *Significance of contribution* | *Relationship between chemical product and application* |
|---|---|
| *Fundamental* | The chemical product is the key component that allows savings in GHG emissions in the first place. |
| *Extensive* | The chemical product is part of the key component and its properties and functions are necessary to effect savings in GHG emissions. |
| *Substantial* | The chemical product does not directly contribute toward savings in GHG emissions, but cannot be easily replaced without changing the GHG emission-saving effect of the solution. |
| *Low* | The chemical product does not contribute directly to saving GHG emissions, but is used in the manufacturing process of a product with a fundamental or extensive GHG saving effect. |
| *Too small to communicate* | The chemical product can be substituted without changing the GHG emission-saving effect of the solution. |

[8] "Ganzheitliche Bilanzierung" (GaBi, versions 5–8.71) software system and databases for life cycle engineering by thinkstep AG, Leinfelden-Echterdingen, Germany and LBP, Chair of Building Physics, University of Stuttgart, Germany

**THE FOLLOWING CRITERIA LISTED IN THE WBCSD AVOIDED EMISSIONS GUIDANCE APPLY TO THE REFERENCE SOLUTION:**

- The reference application serves the same purpose.
- The reference application is used in the same application.
- The reference application is available on the selected market.
- The reference application is interchangeable for the typical user in terms of quality criteria.
- The reference application is as close a match as possible to the Evonik solution.

In accordance with the WBCSD Avoided Emissions Guidance, the results of the reduction calculations are indicated for the value chain of the entire application, because the contribution of a single product to all savings in the value chain is usually difficult to quantify and can therefore be based on assumptions. Table 6 shows the qualitative description of the contributions made by individual products.

Contrary to the specifications of WBCSD Avoided Emissions Guidance, greenhouse gas reductions are not displayed individually for each application of an Evonik product but as an aggregated figure for Evonik.

**THE APPROACH DESCRIBED ABOVE TO CALCULATE $CO_2$EQ EMISSIONS AND REDUCTIONS IS SUBJECT TO CERTAIN LIMITATIONS:**

- Infrastructure measures such as construction of facilities, machinery, and roads, and IT infrastructure are not included.
- Due to the large number of applications of Evonik products, the carbon footprint was calculated only for specific beacon applications that were identified in a screening process. Evonik does not claim to have a complete data inventory on the $CO_2$eq emissions and savings of all its product applications.
- Evonik is aware that the CFEs performed are not comparative LCAs with an external review panel as defined in DIN ISO 14040 ff.

## 2.1 REDUCTIONS IN GREENHOUSE GAS EMISSIONS FROM GREEN TIRE TECHNOLOGY

***HOW DOES THE TECHNOLOGY REDUCE GREENHOUSE GAS EMISSIONS?***

Compared to conventional car tires, the use of the silica-silane-system and a certain polymer blend (solution styrene butadiene rubber (S-SBR) and butadiene rubber (BR))—known as green tire technology—can achieve significant fuel savings and improved wet grip without impacting abrasion resistance (see Figure 4). The lower fuel consumption results in end-users generating fewer $CO_2$eq emissions.

***BACKGROUND***

The rubber compounds in tires have a major impact on the characteristics of tire performance. Organic and inorganic components determine the performance of the tread compound that is in contact with the road surface. Such treads typically contain about 35 percent reinforcing filler, without which rubber compounds could not attain the desired properties such as traction, abrasion resistance, tear resistance, and tear propagation resistance. For decades, these properties could only be achieved with customized carbon blacks.

Today, the replacement of carbon black with silica offers even further improvements in car tires. Due to the different chemical properties of rubber and silica, however, these components are not capable of bonding. This is where bifunctional organic silicon compounds—or organosilanes—come in: They serve as coupling agents that bond the silica and rubber in the manner of a bridge.

Key characteristics such as rolling resistance, wet traction, and abrasion resistance can generally be optimized only to a limited extent, and with negative impact on other properties. In contrast to conventional carbon black filler systems, the use of the silica-silane system allowed for the first time an expansion of the "magic triangle" of tire performance (see Figure 5). Rolling resistance and wet traction were substantially improved without significantly affecting abrasion, and therefore the service life, of the tire. These improvements have resulted in significantly lower fuel consumption for end-users, and therefore in reduced $CO_2$eq emissions.

Please refer to the Appendix for further information on the methodology, the selection of audit parameters, and other reporting elements in accordance with the WBCSD Avoided Emissions Guidance.

**FIGURE 4:** Braking characteristics and fuel consumption

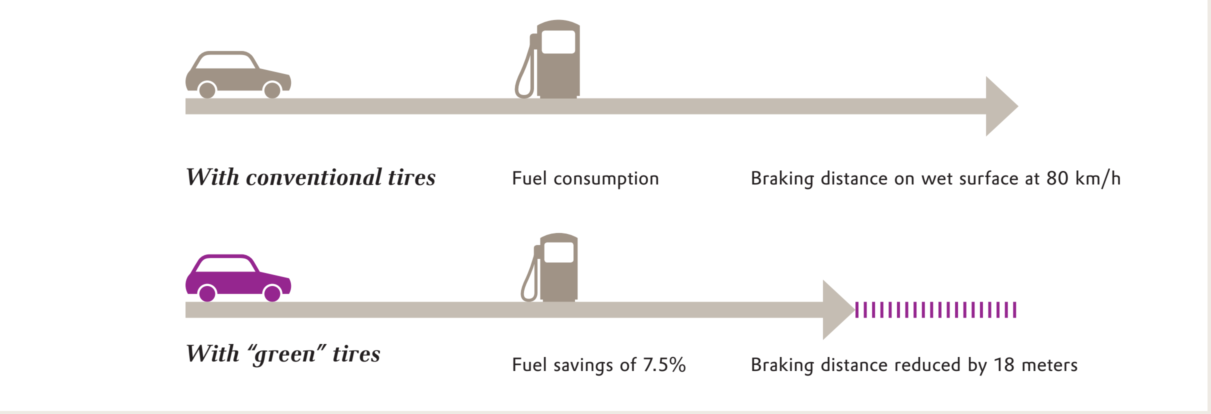
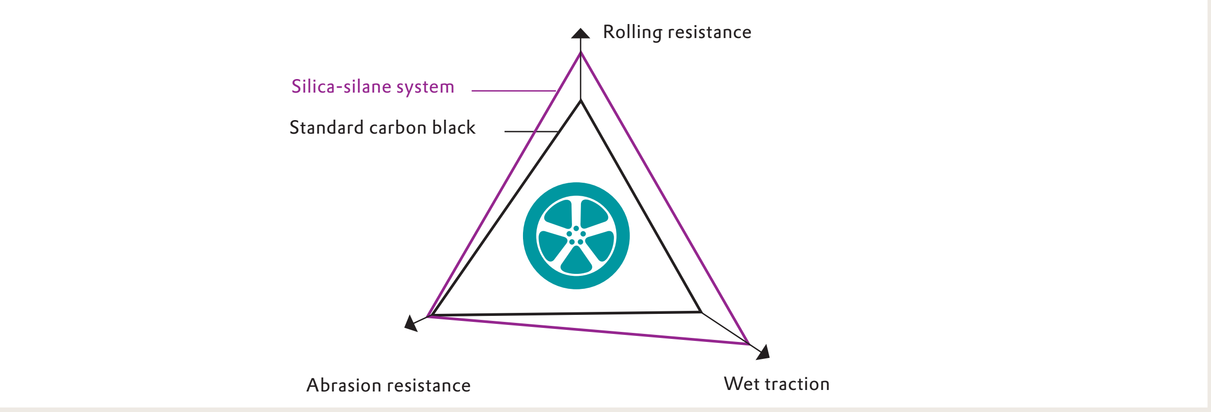



**FIGURE 5:** Expansion of the "magic triangle" by the silica-silane system



## 2.2 REDUCTIONS IN GREENHOUSE GAS EMISSIONS FROM AMINO ACIDS IN ANIMAL FEED

### *HOW DOES THE TECHNOLOGY REDUCE GREENHOUSE GAS EMISSIONS?*

Animal feed is specifically formulated to meet the physiological and nutritional needs of the animals, and in particular the necessary requirements of essential amino acids. Lack of certain amino acids in animal feed can be compensated either by adding a higher percentage of protein-rich feed components such as oil seed, or by fortifying the feed with essential amino acids produced by Evonik for this purpose. Supplementing animal feed with essential amino acids can save significant amounts of feed raw materials, resulting in the freeing up of agricultural land and a corresponding reduction in $CO_2$eq emissions. Furthermore, feed supplementation with these essential amino acids reduces emissions of both nitrogen and greenhouse gases resulting from feeding and excretion, and offers credits for the use of natural manure.

### *BACKGROUND*

**MetAMINO®** is an example of an amino acid containing sulfur. Unlike several other amino acids, it cannot be generated in the animal's own body. Methionine is particularly important in poultry nutrition because of a higher demand for this protein-forming amino acid for feather growth.

Evonik manufactures **MetAMINO®** in a chemical process called the carbonate process (see Figure 6). The company produces all the important intermediates, such as acrolein, methyl mercaptan, and hydrocyanic acid, in an integrated production process at the same site. The raw materials required, such as crude oil and natural gas, are provided by pipeline. All the reaction steps are fully integrated in various circuits with maximum recycling of byproducts and waste streams. Any remaining byproducts and intermediates as well as energy streams can be used by other plants at the same site.

**Biolys®** is the Evonik-specific brand of L-lysine (L-α, ε-diamino-n-caproic acid). It is an essential amino acid contained in almost all proteins, and because of its basic side chain is classified as a basic amino acid. L-lysine is the first limiting essential amino acid in hog farming.

In contrast to MetAMINO®, **Biolys®**—like all the other amino acids in this study—is produced by biotechnological fermentation processes using microorganisms. As a consequence, these amino acids are automatically obtained as the L enantiomer, which is the only biologically effective form. Evonik's commercial L-lysine trade product is Biolys®, which contains L-lysine sulfate and biomass resulting from fermentation as an additional component. The active ingredient content is at least 54.6% L-lysine.

**ThreAMINO®** (L-threonine or L-α- amino-β-hydroxybutyric acid) is a neutral essential amino acid.

Alongside methionine and lysine in poultry farming and lysine and methionine in hog farming, threonine is the next limiting essential amino acid.

Evonik also produces **ThreAMINO®** by a biotechnological method. In this case, however, the amino acid is separated from the biomass at the end of the fermentation process, and the product therefore has an active ingredient content of at least 98.5% free L-threonine, which is significantly higher than in the case of Biolys®.

**TRYPAMINO®** (L-tryptophan or L-2-amino-3-(3′-indolyl)propionic acid) is among the structurally more complex aromatic amino acids.

Tryptophan is the next limiting amino acid after threonine in hog farming.

Evonik also manufactures **TrypAMINO®** in a fermentation process comparable to that described above for ThreAMINO®.

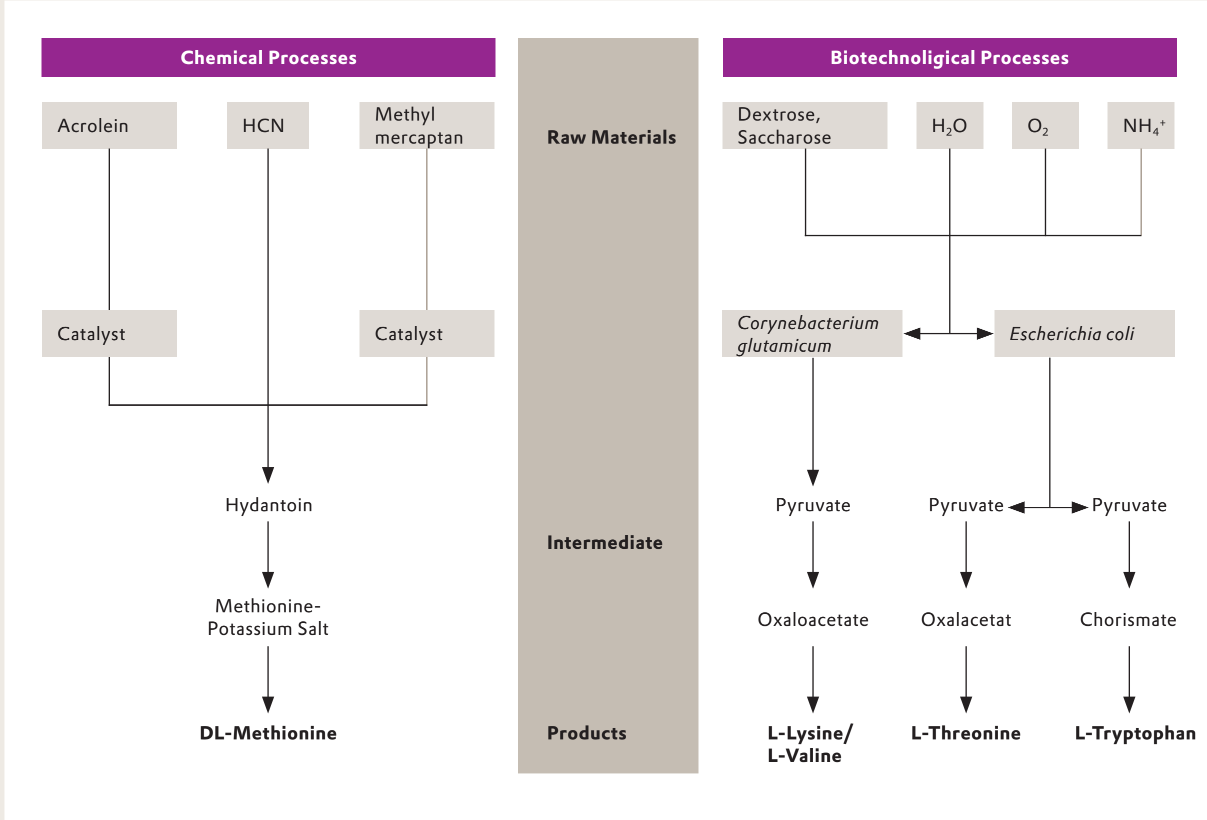
**ValAMINO®** (L-valine or L-2-amino-3-methylbutanoic acid) is an amino acid with a structure relatively similar to that of ThreAMINO®.

In both poultry and hog farming valine is the next limiting amino acid after tryptophan.

**ValAMINO®** is also manufactured in a fermentation process.



**FIGURE 6:** Production of MetAMINO®, Biolys®, ThreAMINO®, TrypAMINO®, and ValAMINO®




Please refer to the Appendix for further information on the methodology, the selection of audit parameters, and other reporting elements in accordance with the WBCSD Avoided Emissions Guidance.

## 2.3 REDUCTIONS IN GREENHOUSE GAS EMISSIONS FROM IMPROVED INSULATION MATERIALS

*HOW DOES THE TECHNOLOGY REDUCE GREENHOUSE GAS EMISSIONS?*

Evonik develops additives, specifically foam stabilizers (TEGOSTAB®), which are very important in foam production and for optimizing foam properties. These polyurethane (PU)-based foams are used, for example, in building insulation or for insulating electrical appliances such as refrigerators. The improvement of insulation properties reduces energy consumption and thus helps reduce greenhouse gas emissions.

*BACKGROUND*

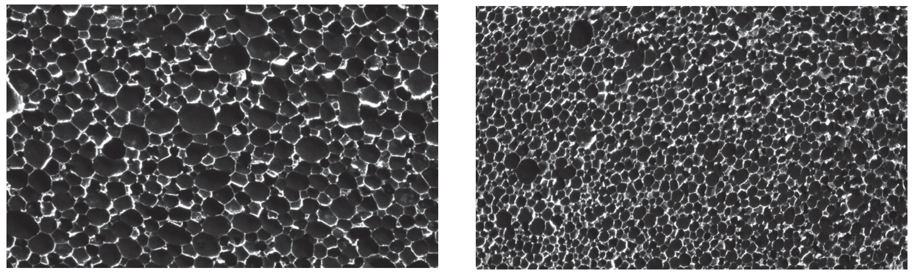
The stabilizers used for the production of polyurethane foam consist of polyether-modified polysiloxanes. In these surface-active substances, the siloxane chain represents the hydrophobic part of the molecule that is located at the surface of the foam cells; this lowers the surface tension and thereby stabilizes the foam. The polyether groups, as the hydrophilic part of the molecule, are responsible for compatibilization with the PU matrix, which makes the surface activity possible.

To achieve maximum foam stabilization and the particularly fine-cell foam structure resulting from this, the molecular structure has to be adapted to the individual foam formulation. Custom-tailored foam stabilizers therefore give rise to particularly good insulating properties in the finished foam product.

In addition to improving the fine-cell structure of foam, customized foam stabilizers also serve to optimize the processing properties of a foam system. They minimize irregularities such as cavities (undesirable hollow spaces) in the foam and help achieve a more homogeneous density distribution, which also contributes to a further improvement of insulating properties.

Please refer to the Appendix for further information on the methodology, the selection of audit parameters, and other reporting elements in accordance with the WBCSD Avoided Emissions Guidance.

**FIGURE 7:** Micrographs of the cell structure of foam systems with standard additives and with new additives from Evonik



*Micrographs illustrate the positive effect of optimized Evonik foam stabilizers on the fine-cell structure of rigid polyurethane foams. The top image is a micrograph of the cell structure of a modern foam system for refrigerator insulation; the bottom image shows (at the same magnification) foam containing the same polyurethane system, in which the standard additives have been replaced by the new Evonik additives. The finer the cell structure of the foam, the lower the thermal radiation it can transmit, which results in a lower overall thermal conductivity.*

## 2.4 REDUCTIONS IN GREENHOUSE GAS EMISSIONS FROM IMPROVED HYDRAULIC OILS

*HOW DOES THE TECHNOLOGY REDUCE GREENHOUSE GAS EMISSIONS?*

Mobile construction machines consume the bulk of their required energy in their hydraulic units. The use of DYNAVIS® technology can achieve significant fuel savings and higher productivity (Figure 8) compared with conventional (monograde) hydraulic oil. Lower fuel consumption means that end users generate fewer greenhouse gases ($CO_2$eq), especially carbon dioxide.

*BACKGROUND*

Hydraulic fluid plays a major role in the use of hydraulic construction machinery such as excavators and wheel loaders. Its viscosity and viscosity-temperature behavior has a considerable impact on the operation of such hydraulic machinery (Figure 9). The oil additives specialists of Evonik have performed field tests with hydraulic excavators of various sizes in accordance with a defined protocol that reflects the typical work modes of such machinery.

The viscosity of a hydraulic fluid decreases with increasing temperature. This dependency can be minimized with DYNAVIS® technology, based on fluid formulations with viscosity index improvers of high shear stability, which allows for energy savings.

At low temperatures, such thinner oils reduce internal friction and enable an easier cold start and warm-up phase. At high temperatures, a more viscous oil prevents an increase in internal return flow losses in the hydraulic pumps, thereby increasing volumetric efficiency. This ensures that the viscosity does not fall below a prescribed minimum, thus ruling out overheating, increased wear, and premature failure. For end users these improvements result in significantly higher productivity and lower fuel consumption, and therefore in reduced $CO_2$eq emissions.

Please refer to the Appendix for further information on the methodology, the selection of audit parameters, and other reporting elements in accordance with the WBCSD Avoided Emissions Guidance.

**FIGURE 8:** Comparison of monograde and DYNAVIS® hydraulic fluids and effects on the application

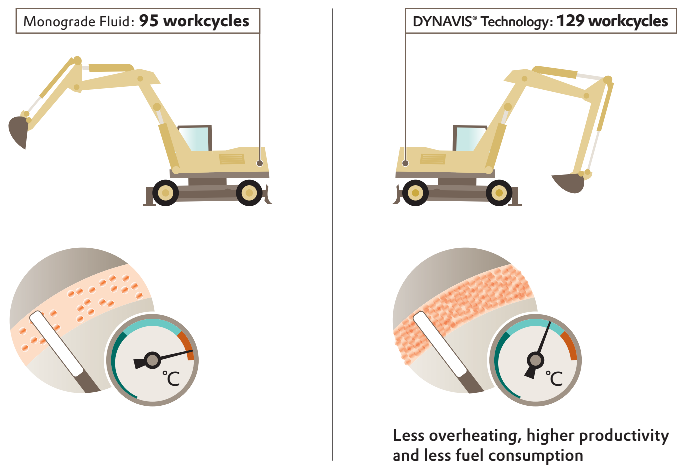
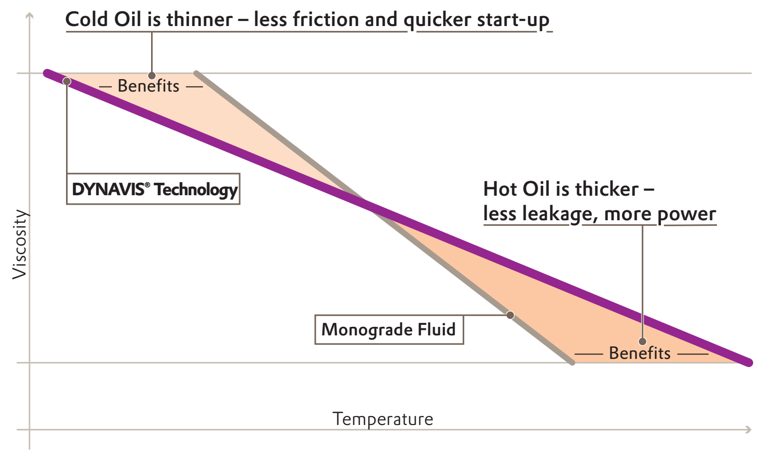


**FIGURE 9:** Dependence of viscosity on temperature, and positive effects on the application




# 3

# Results

Compared with their established alternatives, the applications investigated for selected beacon products save the volumes of greenhouse gas emissions shown in Table 7.

These reductions are caused by applications of the following four products: green tire technology, amino acids in animal feed, foam stabilizers for insulation materials, and oil additives in hydraulic oils. The savings were generated over the life cycle of applications produced with the product volumes sold by Evonik in the specified year.

The WBCSD Avoided Emissions Guidance recommends reporting the calculated savings in the entire value chain for the selected application. Table 7 reports the total savings for selected applications in which Evonik products are used. The contributions of the individual products are described in qualitative terms (see Appendix), using the significance categories listed in Table 6. Greenhouse gas emissions saved in 2015 did not differ much from those in 2014, despite increased production volumes for individual emission-reducing products. The changes can be ascribed mainly to a recalculation of the savings for green tires. The associated life cycle assessment was updated in 2015. The increase in greenhouse gas savings from 2015 to 2016 is ascribed to a higher sales volume for green tire technology as well as further regionalization of sales volume for foam stabilizers for insulation materials. These effects offset the decline in saved greenhouse gases due to the absence of the beacon product of specialty oxides in compact fluorescent lamps; these were included in the calculations in the previous year but will not be considered from 2016 onward due to a decline in sales volumes. The increase in reduced emissions from 2016 to 2017 and from 2017 to 2018 is ascribed to increased sales volumes.

These $CO_2$eq savings should not be compared directly with the Evonik Carbon Footprint: The latter refers to emissions associated with the manufacture of Evonik products, generally intermediates (and includes production, supply-chain, and disposal emissions, without taking the use phase into account). By contrast, the $CO_2$eq savings have been calculated on the basis of life cycle emissions for applications of selected Evonik products.

**TABLE 7:** Trend in greenhouse gas savings over the life cycle of applications of selected Evonik products sold in the specified year

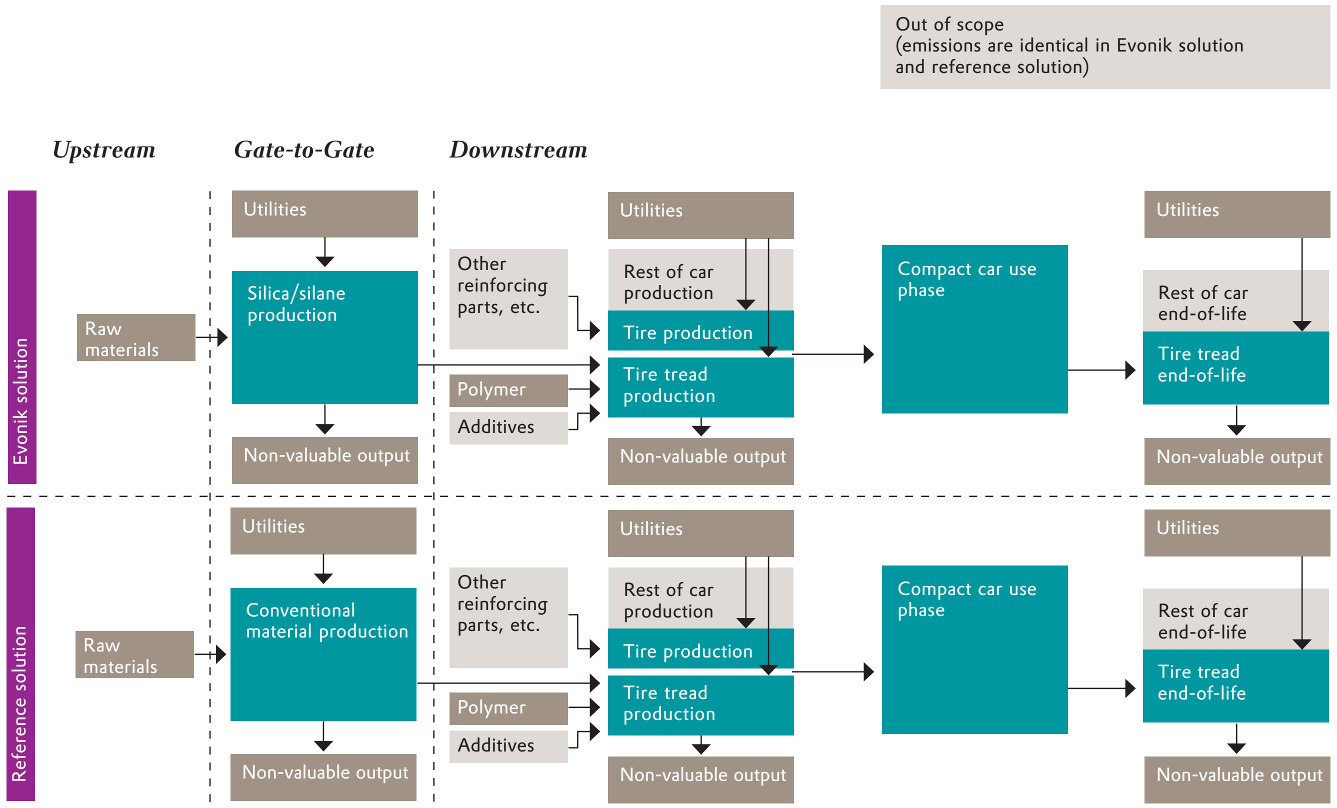
| | *2014* | *2015* | *2016* | *2017* | *2018* |
|---|---|---|---|---|---|
| *$CO_2$eq savings [in millions of metric tons]* | 92.5 | 92.2 | 95.2 | 101.8 | **108.0** |

# APPENDIX

## *Reductions in greenhouse gas emissions from green tire technology*

| | |
|---|---|
| *Objective of the study* | Calculation of greenhouse gas emissions avoided by the use of a silica-silane system in a specific rubber blend (S-SBR, BR) (green tire) as a tread component, as compared with the use of carbon black and emulsion styrene butadiene rubber (E-SBR) (carbon black tire), in a compact car tire over 150,000 km. |
| *Type of comparison* | Category 3 (chemical product vs. chemical product/technology) |
| *Reference solution* | Carbon black as filler material and E-SBR as tread component. Both the “green tire” and the tire with conventional tread fulfill the same function, are at the same level of the value chain, are used in the same application, and are interchangeable for a typical customer as commercially available solutions. |
| *Functional unit* | The use of silica-silane and rubber compound (S-SBR, BR) (Evonik's solution) or carbon black and E-SBR (reference solution) as components in a compact car tire over 150,000 km (“cradle to grave”). |
| *Temporal and geographical reference* | The life cycle assessment including the external panel review was completed in 2016. The production data utilized refer to the year 2014 and to sites in Germany and Belgium. Sales volumes of Evonik silica and silanes for 2017 were used to calculate overall savings. |
| *Calculation method* | To determine savings in greenhouse gas emissions, the internal Evonik Life Cycle Management team, working in close cooperation with Resource Efficiency GmbH, performed a Life Cycle Assessment (LCA) in 2015 in accordance with the requirements of DIN ISO 14040 ff. As part of the LCA, the green tire and the conventional carbon black tire were compared over their entire life cycle. To take the use phase into consideration, the required volume of tread components was included in the accounting for the distance of 150,000 km, and the differences in fuel consumption and the associated greenhouse gas emissions were calculated for both systems. For reasons of simplicity, identical emissions (for example, those associated with the manufacture and disposal of the rest of the vehicle) were not taken into account. This approach had no impact on the amount of savings. The greenhouse gas emissions are calculated from the sum of the emissions arising during production of the respective systems as well as the emissions generated during the use phase and in the end-of-life phase. The difference between the green tire and the carbon black tire ultimately shows the savings in greenhouse gas emissions. |
| *Significance of the contribution of the Evonik product to overall reductions in the application* | The calculated reductions refer to the entire value chain of the selected application. Evonik silica and silanes are however part of the key components and their properties and functions are necessary and responsible for achieving reductions in greenhouse gas emissions. Green tire technology therefore makes an extensive contribution to reducing greenhouse gas emissions. |
| *References* | A detailed list of the referenced literature is available from Evonik on request. |
| *Supplementary notes* | The life cycle assessment was externally reviewed and certified as part of a panel review. No scenario analyses for future developments were performed. Allocation of the avoided emissions to companies involved in the value chain was not performed due to the extensive contribution of the Evonik products to green tire technology. |

**FIGURE 10:** Overview of audit parameters for calculating reductions in greenhouse gas emissions from green tires



## Reductions in greenhouse gas emissions from amino acids in animal feed

*Objective of the study*

Calculation of greenhouse gas emissions avoided by the use of amino acids in animal feed, compared to feed without amino acid supplementation. The calculation is based on a life cycle assessment that was externally reviewed by TÜV Rheinland in 2015. The study assesses the reduction potential of the five first limiting amino acids in the environmental categories of global warming, eutrophication, and acidification, in typical conventional poultry and hog diets based on current farming data. It was performed as a comparative life cycle analysis in accordance with the requirements of DIN ISO 14040 ff. The target groups of the study are mainly representatives and associations of environmental protection and agriculture, political decision makers, and representatives of the food industry. The study was commissioned by Evonik's former Health & Nutrition Business Unit (now Evonik Nutrition & Care GmbH) and was performed by Evonik's internal Life Cycle Management team. For further information please refer to certificate number 0000027153 at https://www.certipedia.com/.

*Type of comparison*

Category 1 (chemical product vs. non-use of the product or technology)

*Reference solution*

The life cycle assessment compared three options:
- Addition of a defined pre-mix of the pure amino acids DL-methionine, L-lysine, L-threonine, L-tryptophan, and L-valine
- Increase of the corresponding amino acid content with a higher proportion of raw feed rich in amino acids, such as oil seed
- A second non-supplemented option covers the European practice of using locally produced rapeseed meal instead of imported soy bean meal.

All mixes fulfill the same function, are at the same level of the value chain, are used in the same application, and are interchangeable for a typical customer as commercially available solutions.

*Functional unit*

The functional unit and the reference flow were defined as 1 kg of a supplemented amino acid mix consisting of DL-methionine, L-lysine, L-threonine (hog farming only), and L-valine or an equivalent volume of amino acids in feed plants (e.g., oil seed).

*Temporal and geographical reference*

The primary data were compiled for production of the five amino acids with reference year 2013 and 2014 and provided by the operating units. The secondary data of the background system, i.e. energy provision, agricultural and mineral raw materials, transports and disposal, were mainly taken from the GaBi database [GaBi 2019] by thinkstep AG. Additionally, some processes were estimated based on literature data. Ecoinvent data [Ecoinvent 2008] were used in isolated cases where no GaBi data record was available. If available, data records were selected for the corresponding site:
- Belgium for DL-methionine
- USA for L-lysine
- Hungary for L-threonine
- Slovakia for L-tryptophan
- Slovakia for L-valine based on a pilot process
- Additional lifecycle phases in Germany.

The global sales volumes for amino acids supplied by Evonik to the feed industry for 2018 were used to calculate total savings.

*Calculation method*

Accounting for the individual scenarios with reference to the corresponding specific feed mixes is always in accordance with the "cradle to grave" principle, i.e., from the provision of raw materials for the individually added amino acids, through agricultural cultivation of feed raw materials, production of mineral fertilizers for agricultural production, expenditures for harvesting, intermediate processing of agricultural raw materials, and all transport-related expenditures for all utilized raw materials, intermediates, and end products in technical terms, to emissions associated with feeding and excretion.



*Significance of the contribution of the Evonik product to the total reductions for the application*

The calculated reductions refer to the entire value chain of the selected application. However, the Evonik amino acids are the key components responsible for achieving reductions in greenhouse gas emissions and therefore make a fundamental contribution to the savings.

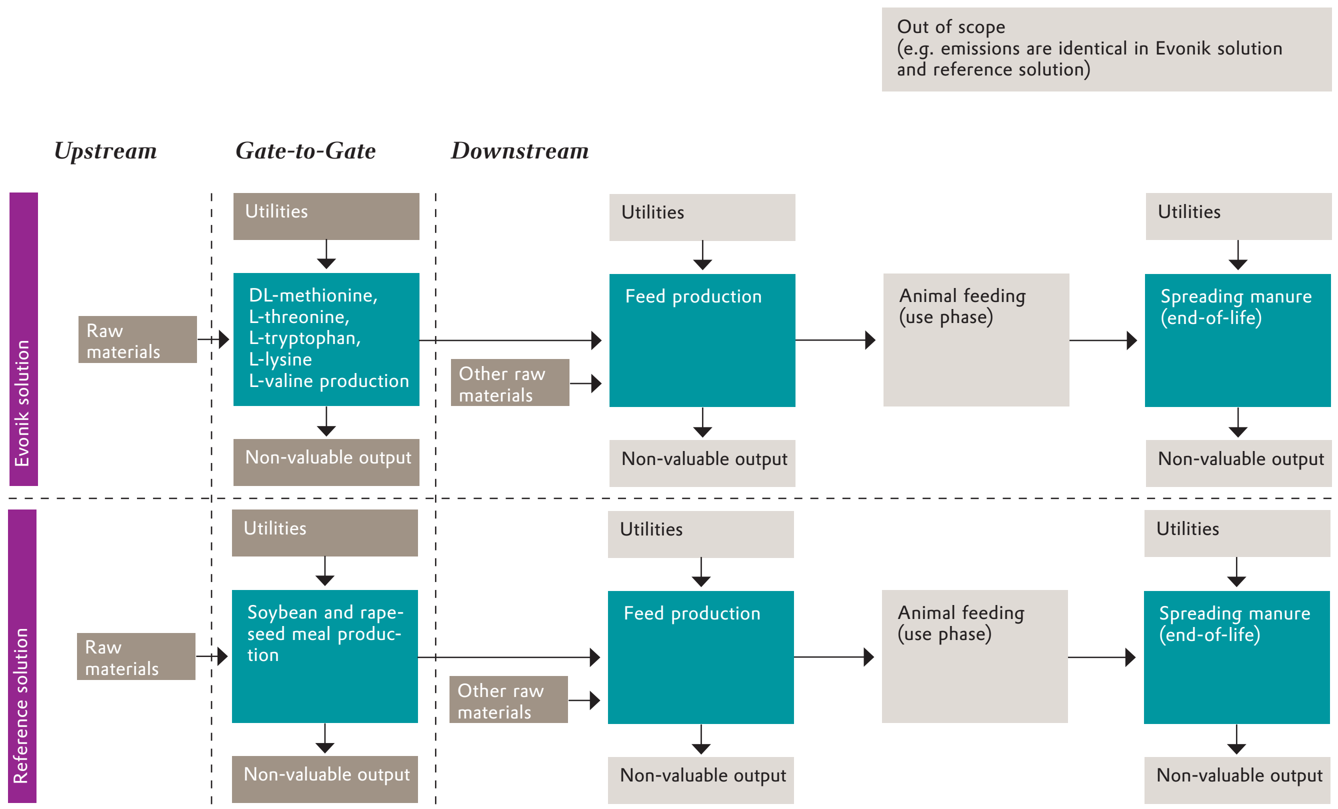
*References*

A detailed list of the referenced literature is available from Evonik on request.

*Supplementary notes*

No scenario analyses for future developments were performed. Allocation of avoided emissions to the companies involved in the value chain was not performed due to the fundamental contribution of Evonik's amino acids.

**FIGURE 11:** Overview of audit parameters for calculating reductions in greenhouse gas emissions from amino acids in animal feed



## *Reductions in greenhouse gas emissions from optimized insulation materials*

| | |
|---|---|
| ***Objective of the study*** | Calculation of greenhouse gas emissions avoided by the use of foam stabilizers in building insulation and in the insulation of refrigerators. |
| ***Type of comparison*** | Category 3 (chemical product vs. chemical product / technology) |
| ***Reference solution*** | Conventional, non-optimized foam stabilizers. The reference solution fulfills the same function, is at the same level of the value chain, is used in the same applications, and is interchangeable for a typical customer as a commercially available solution. |
| ***Functional unit*** | One metric ton of foam stabilizers in PU foam with a life expectancy of 12 years (refrigerator insulation) and 45 years (building insulation) (use phase only). |
| ***Temporal and geographical reference*** | The savings in the use phase were calculated for the "refrigerator" use case for the USA, Europe, and China regions, and for the "building insulation" use case for the USA, Europe, China, and South Korea regions. For this purpose, the following parameters were determined for the "refrigerator" use case for each region, to ensure that calculation of the greenhouse gas emissions saved is as regionally specific as possible: refrigerator volume, proportion of additives in the polyurethane foam, and energy consumption of the refrigerator. Using an average energy mix calculated for each region from GaBi data provided by thinkstep AG, it was ultimately possible to calculate greenhouse gas emission savings for the sales volumes of foam stabilizers in the corresponding regions for 2018.<br>The following regionally specific parameters were determined for the "building insulation" use case: U-value (measure of a building component's thermal insulation), lambda value (measure of a material's thermal conductivity), and heating degree days. Using a calculated region-specific energy mix for building heating, it was ultimately possible to calculate savings in greenhouse gas emissions for the sales volumes of foam stabilizers in the corresponding regions for 2018.<br>The total savings were calculated as the sum of the greenhouse gas reductions already determined from the two use cases described above. |
| ***Calculation method*** | To determine the reductions in greenhouse gas emissions, the internal Evonik Life Cycle Management team, working in close cooperation with the Comfort & Insulation Business Line of Evonik Nutrition and Care GmbH, analyzed two use cases as part of a Carbon Footprint Estimation (CFE):<br>the use of foam stabilizers in building insulation and in the insulation of refrigerators.<br>Foam stabilizers optimized by Evonik were compared with the effect of insulation materials manufactured with conventional foam stabilizers. In both cases, energy savings were determined on the basis of suitable assumptions and converted into greenhouse gas emission savings.<br>For reasons of simplicity, identical emissions (for example, those associated with the manufacture and disposal of foam stabilizers) were not taken into account. This approach had no impact on the amount of savings. |
| ***Significance of the contribution of the Evonik product to the total reductions for the application*** | The calculated reductions refer to the entire value chain of the two selected applications. However, the optimized Evonik foam stabilizers are the key components responsible for achieving reductions in greenhouse gas emission. The optimized foam stabilizers therefore make a fundamental contribution to the amount of avoided greenhouse gas emissions. |
| ***Supplementary notes*** | No scenario analyses for future developments were performed. Allocation of the avoided emissions to the companies involved in the value chain was not performed due to the fundamental contribution of the Evonik products. |

**FIGURE 12:** Overview of audit parameters for calculating reductions in greenhouse gas emissions from improved insulation materials (refrigerator insulation)

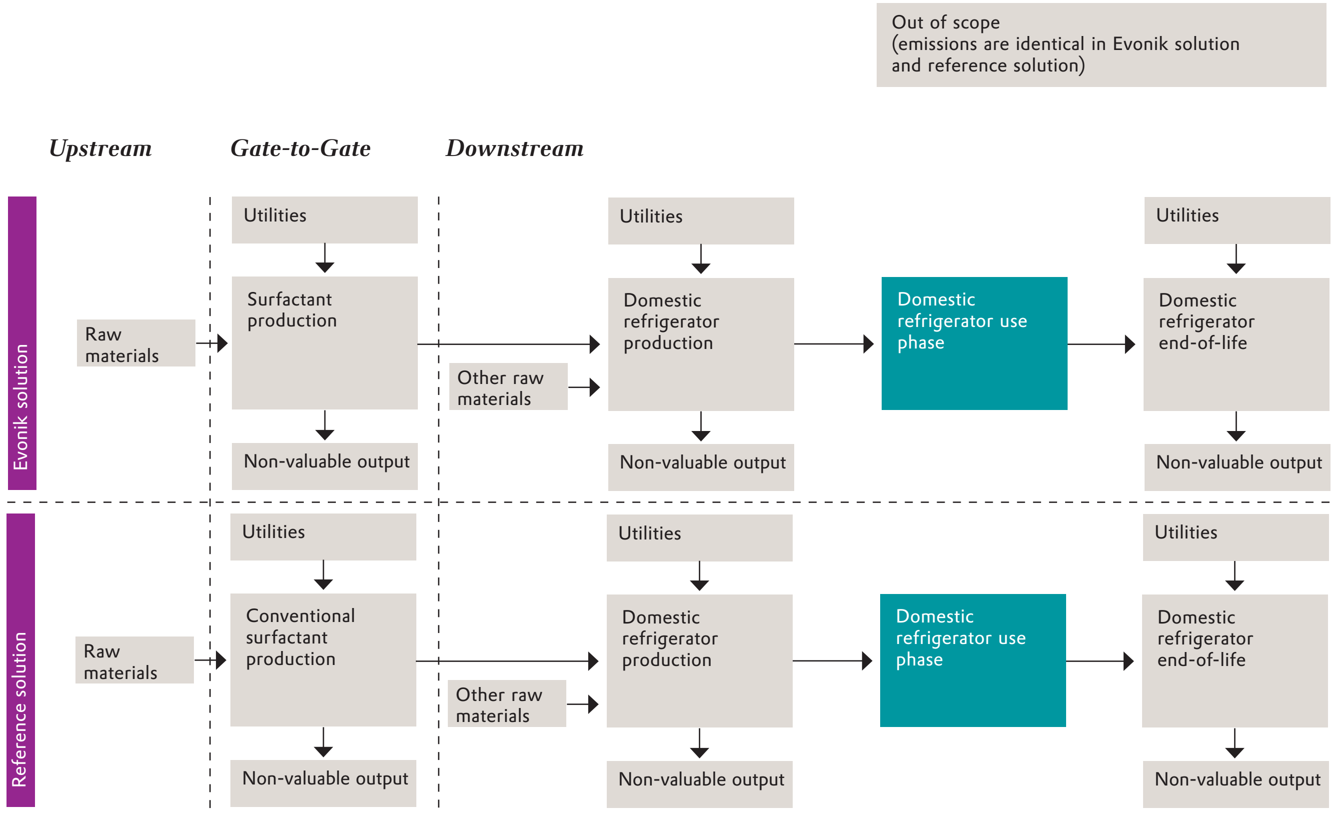
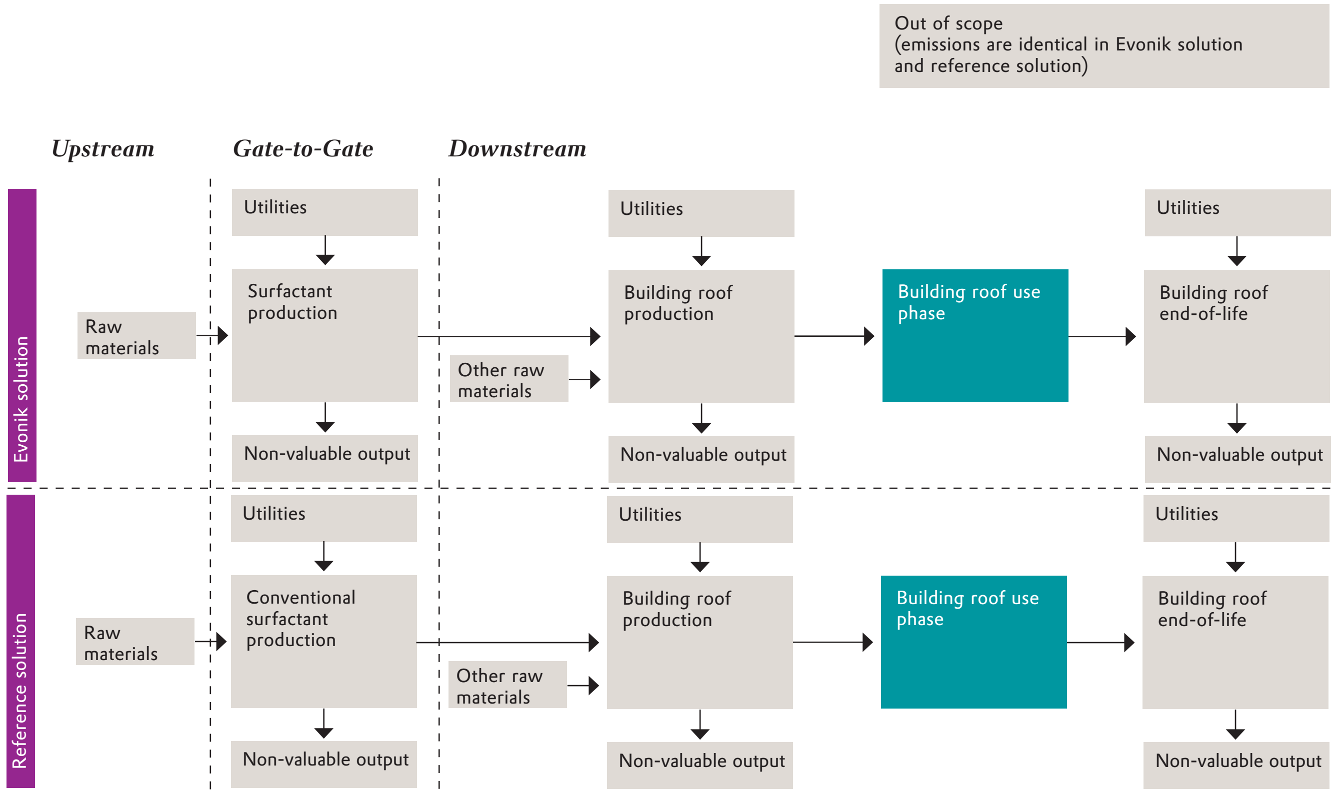


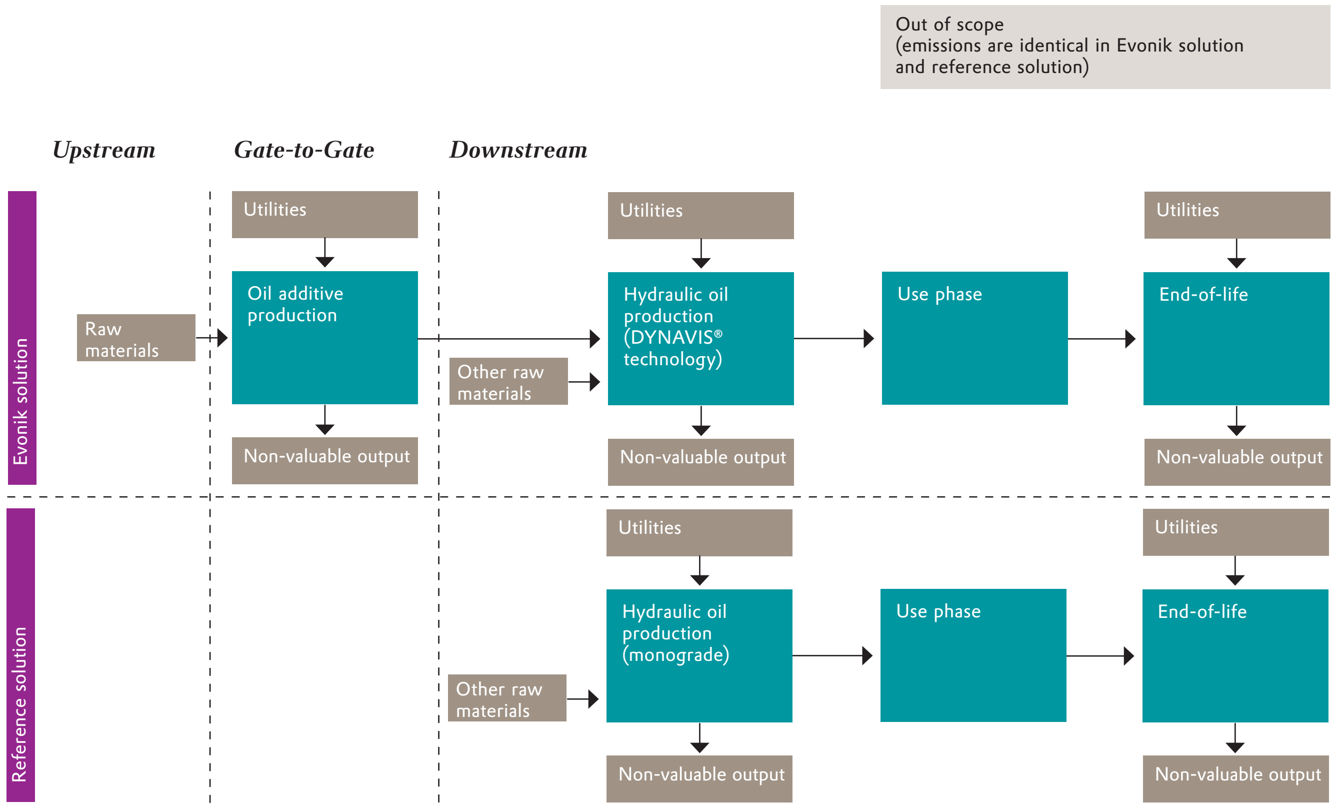

**FIGURE 13:** Overview of audit parameters for calculating reductions in greenhouse gas emissions from improved insulation materials (building insulation)



### *Reductions in greenhouse gas emissions from improved hydraulic oils*

| | |
|---|---|
| *Objective of the study* | Calculation of greenhouse gas emissions avoided by using DYNAVIS® technology in hydraulic oils of hydraulic construction machinery as compared with conventional hydraulic oils. |
| *Type of comparison* | Category 3 (chemical product vs. chemical product / technology) |
| *Reference solution* | Conventional hydraulic oils without DYNAVIS® technology (monograde). The reference solution fulfills the same function, is at the same level of the value chain, is used in the same applications, and is interchangeable for a typical customer as a commercially available solution. |
| *Functional unit* | Operation of a hydraulic construction machine over a period of 2,000 hours |
| *Temporal and geographical reference* | The model is based mainly on data from Germany; important raw materials come from Asia. The reference year is 2011. In addition, the reductions refer to global use of the DYNAVIS® technology. The global sales volumes of the corresponding Evonik oil additive to the hydraulic oil industry for 2018 were used to calculate the total savings. |
| *Calculation method* | The internal Evonik Life Cycle Management team, working in close cooperation with the Oil Additives Business Line of Evonik Resource Efficiency GmbH, performed a Life Cycle Assessment (LCA) in 2013 to determine savings in greenhouse gas emissions. As part of the LCA, two different hydraulic oils, a fluid based on Evonik DYNAVIS® technology and a conventional monograde hydraulic oil, were compared across their entire life cycle (cradle to grave). To take the use phase into account, both hydraulic oils were used in field tests in a mid-sized excavator with an oil change interval of 2,000 hours. For reasons of simplicity, identical emissions (for example, those associated with the manufacture and disposal of the rest of the vehicle other than the hydraulic oils) were not taken into account. This approach had no impact on the amount of the savings determined. DYNAVIS® technology was used less often globally than conventional hydraulic oil in 2018. Reductions in greenhouse gas emissions were calculated on the basis of emissions in the life cycles of the hydraulic oils and the fuel savings determined for the hydraulic oil based on DYNAVIS® technology (use phase). |
| *Significance of the contribution of the Evonik product to the total reductions for the application* | The calculated reductions refer to the entire value chain of the selected application. However, Evonik's DYNAVIS® technology is the key component responsible for achieving reductions in greenhouse gas emissions. DYNAVIS® technology therefore makes a fundamental contribution to the amount of avoided greenhouse gas emissions. |
| *Supplementary notes* | No scenario analyses for future developments were performed. Allocation of avoided emissions to the companies involved in the value chain was not performed due to the fundamental contribution of the Evonik product. |

**FIGURE 14:** Overview of audit parameters for calculating reductions in greenhouse gas emissions due to improved hydraulic oils



*Independent Practitioner's Report on a Limited Assurance Engagement on Greenhouse Gas Emission Data To Evonik Industries AG, Essen*

Our company has performed a limited assurance engagement of the information marked "√" in the Evonik Carbon Footprint 2018 brochure of Evonik Industries AG, Essen (referred to below as "Company") for the period from January 1, 2018 to December 31, 2018 (referred to below as "Greenhouse Gas Emission Data"). Our task here refers exclusively to the data marked "√".

## MANAGEMENT'S RESPONSIBILITY

Company's Executive Board is responsible for the compilation of Greenhouse Gas Emission Data in accordance with the criteria of relevance, completeness, consistency, transparency, and accuracy (referred to below as "GHG Protocol Criteria") set out on pages 8 and 9 of the publication "A Corporate Accounting and Reporting Standard—Revised Edition" of the Greenhouse Gas Protocol Initiative (World Business Council of Sustainable Development / World Resources Institute), and is also responsible for the selection of the data to be assessed.

This responsibility of Company's management includes the selection and application of suitable methods to compile Greenhouse Gas Emission Data, while also arriving at assumptions and estimates of individual Greenhouse Gas Emission Data that are plausible under the given circumstances. Furthermore, this responsibility includes the internal controls that the management deems necessary to allow the compilation of Greenhouse Gas Emission Data that is free from substantial—intentional or unintentional—errors.

## INDEPENDENCE AND QUALITY ASSURANCE OF THE AUDITING COMPANY

We have complied with the German professional regulations for the independence of auditors along with further professional conduct requirements.

Our auditing company applies national statutory regulations and professional publications, in particular the Code of Professional Practice for Auditors and Certified Public Accountants (BS WP/vBP) as well as the IDW quality assurance standards 1, Requirements for Quality Assurance in Auditing Practice (IDW QS 1), issued by the Institute of Public Auditors in Germany (IDW). Accordingly, our company maintains an extensive quality assurance system, which includes documented regulations and measures regarding compliance with professional conduct requirements, professional standards, and the relevant statutory and other legal requirements.

## AUDITOR'S RESPONSIBILITY

Our responsibility is to express an opinion on Greenhouse Gas Emission Data marked with "√" on the basis of our audit activities. The assessment of external documentation sources or expert opinions to which reference is made in the context of Greenhouse Gas Emission Data is not included in the scope of our tasks.

We conducted our engagement in accordance with the International Standard on Assurance Engagements (ISAE) 3000 (Revised): "Assurance Engagements other than Audits or Reviews of Historical Financial Information," published by the IAASB. According to this standard, we must plan and carry out the audit to obtain limited assurance as to whether any matters have come to our attention that cause us to believe that data marked "√" in the Greenhouse Gas Emission Data of the company for the period January 1, 2018 to December 31, 2018 were not compiled substantially in accordance with the GHG Protocol Criteria. This does not mean that a separate audit opinion will be provided for every marked data item.

The scope of review in limited assurance engagements is more restricted than for reasonable assurance engagements, and therefore significantly less assurance is obtained than in a reasonable assurance engagement. The procedures selected depend on the practitioner's proper judgment.

Within the scope of our engagement we have performed the following procedures:

- Inspection of the documentation of the systems and processes as well as of other documents pertaining to the Greenhouse Gas Emission Data for 2018.
- Evaluation of the procedures and systems that represent the basis for determination of baseline/reference values for selected emission-avoiding products and solutions within the Greenhouse Gas Emission Data for 2018.
- Interviews with employees responsible for the preparation of the Greenhouse Gas Emission Data for 2018.
- Interviews with employees from selected business lines who were involved in performing the calculations for selected emission-avoiding products and solutions.
- Understanding the individual calculation steps for both the total greenhouse gas emissions and emissions avoided through the use of products and solutions of the product portfolio in the fiscal year 2018.
- Checking consistent application of baselines and reference values for selected emission-avoiding products and solutions.
- Comparing selected transaction data used in the calculations with information from company-internal systems.

## ASSURANCE CONCLUSION

On the basis of the engagement activities performed and the assurance level achieved, we have not become aware of any circumstances allowing us to conclude that the Company's Greenhouse Gas Emission Data marked with "√" for the period from January 1 to December 31, 2018 were not compiled substantially in accordance with the GHG Protocol Criteria.

## EMPHASIS OF MATTER; RECOMMENDATIONS

Without qualifying our above conclusion, we point out that quantification of greenhouse gas emissions is based in part on assumptions and estimates.

## GENERAL TERMS OF ENGAGEMENT

We issue this report on the basis of the engagement agreed with Company. The audit was performed for Company's purposes and the report is intended exclusively for Company's information on the result of the audit. The report is not intended as a basis for third-party (financial) decisions. We are responsible only to Company and do not accept any liability for third parties.

Essen, June 19, 2019
**PricewaterhouseCoopers GmbH | Auditors**

Hendrik Fink
Auditor (Wirtschaftsprüfer)

ppa. Robert Prengel

**EVONIK INDUSTRIES AG**
Rodenbacher Chaussee 4
63457 Hanau
Germany
lca@evonik.com
**www.evonik.com**