EDITION 2023

Next Generation Solutions

THEIR CONTRIBUTION TO THE SUSTAINABILITY FOCUS AREAS

EVONIK
Leading Beyond Chemistry

Next Generation Solutions

THEIR CONTRIBUTION TO THE SUSTAINABILITY FOCUS AREAS

The intention of this brochure is to provide more detailed information on selected products and solutions with a clearly positive sustainability profile, i.e. our Evonik Next Generation Solutions (NGSs). Special attention is paid to the contribution of these NGSs to the four Sustainability Focus Areas (SFAs) – that bundle our contributions to a sustainable transformation – and describe their sustainability benefits (also referred to as their handprint).

After introducing the SFAs and the Evonik Portfolio Sustainability Assessment (PSA) methodology, the handprint evaluation of some NGSs is detailed.

The handprint of selected NGSs will be described including the report of the greenhouse gas emission reductions – so-called "avoided emissions" for the year 2023[1]. Their associated environmental or social impact will be detailed paying special attention to their contribution to one of the four sustainability focus areas if credible quantification data is available.

Where possible, a quantitative estimation of the handprint is given. Due to the profound interest in quantitative and precise information on handprints in some value chains and good data availability, several examples from automotive and food applications are described in this brochure.

[1] Since 2022, "avoided emissions" are reported in the Next Generation Solutions brochure Cf. https://corporate.evonik.com/de/nachhaltigkeit

AVOIDED EMISSIONS THROUGH THE USE OF SELECTED EVONIK PRODUCTS:

48.2

million tons CO_2e quantified

378

kt ressources quantified

Content

Evonik's four Sustainability Focus Areas

1

Evonik's four Sustainability Focus Areas (SFAs)

Our contributions to sustainable transformation are bundled in the four Sustainability Focus Areas (SFAs):
- Fight Climate Change
- Drive Circularity
- Safeguard Ecosystems and
- Ensure Health & Wellbeing.

Within each SFA, Evonik is working on reducing its ecological (and social) footprint and enhancing its handprint resulting from product application.

The following page summarizes our understanding and definition of each SFA, the topics addressed, as well as the relevant United Nations' Sustainable Development Goals (SDGs).

For each SFA the current state of our impacts, risks and opportunities as well as our next actions and ambitions are described.

In the Figure 1, a mapping is made between our opportunity markets and impacts in the 4 Sustainability Focus Areas.

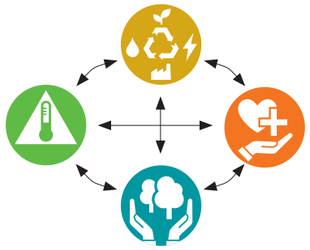


Figure 1 Mapping between opportunity markets and our impact in the 4 SFAs.

Markets				
Renewable energy/transformation	Biogas, biofuel, wind, solar, hydrogen, energy storage/distribution			
Energy efficiency & mobility	Advanced materials, e-mobility, batteries			
Green building	Insulation, advanced construction materials			Low VOC, safe materials
Sustainable water/sanitation			Wastewater prevention & treatment	
Pollution prevention/waste	CCS, CCU	Enable recycling	Pollution prevention & control, environmental remediation	
Sustainable consumer goods		Circular carbon-based ingredients		Low VOC, safe materials
Sustainable agriculture/food			Resource efficient, low pollution animal nutrition	
Pharma & medical therapies				Drug & vaccine delivery, cell-culture based therapy
Impacts	**Fight Climate Change**	**Drive Circularity**	**Safeguard Ecosystems**	**Ensure Health & Wellbeing**
	• Energy efficiency • Emission reduction • Climate adaptation	• Circular materials • Reduce, recycle, reuse • Repurpose, repair • Remanufacture, refurbish, renature	• Water & terrestrical ecosystems preservation • Reduce emission & leaching of disputed and persistent chemicals	• Reduce hazard exposure • Replace disputed chemicals • More effective therapies

FIGHT CLIMATE CHANGE

- Reduce Scope 1 and 2 greenhouse gas (GHG) emissions
- Reduce Scope 3 GHG emissions
- Reduce Scope 1–3 carbon intensity
- Reduce specific energy use
- Increase share of renewable electricity
- Enable avoided emissions (e.g. through advanced materials, e-mobility, batteries, insulation, advanced construction materials)
- Provide solutions for renewable energy (biogas, biofuel, wind, solar), hydrogen, energy storage & distribution
- Enable solutions for Carbon Capture and Storage (CCS) and Carbon Capture and Utilization (CCU)

DRIVE CIRCULARITY

- Increase share of circular raw materials[2]
- Enable resource reduction by process optimization, enhancing durability or other options for lifetime extension like reuse, refurbish or repair
- Enable or improve materials for recycling (mechanical or chemical)
- Ensure biodegradability for dissipative product applications

SAFEGUARD ECOSYSTEMS

- Establish water stewardship (reducing freshwater intake at sites and Blue Water Consumption[3] in areas with high water risks along the value chain.
- Enable water savings in product's application and water quality improvements.)
- Establish ecosystem stewardship with a focus on land use for bio-based raw materials and proximity of sites to protected areas.
- Use bio-based raw materials which comply with environmental and social sustainability requirements
- Enabling resource efficient and low pollution animal nutrition by reducing eutrophication and acidification
- Enabling pollution prevention and control
- Enabling waste water prevention and treatment
- Reduce emissions and leaching of disputed chemicals, microplastic, and other persistent chemicals

ENSURE HEALTH & WELLBEING

- Reduce hazardous emissions
- Reduce hazardous solid waste
- Reduce sales with disputed chemicals
- Enable customers to use safe and sustainable chemicals
- Enable reduced exposure to Volatile Organic Compounds (low VOC) and microparticulate matter and enable safe materials
- Grow number of patients or vulnerable consumers reached with health outcomes
- Enable medical and pharmaceutical therapies, e.g. drug and vaccine delivery and cell culture based therapies

[2] There are three sources for circular feedstock: recycled feedstock (can come from fossil- or bio-based waste), bio-based feedstock, CO_2-based feedstock (could be produced using different technologies).

[3] Blue Water Consumption (BWC) refers to surface or groundwater that is either evaporated, incorporated into a product or taken from one water body and returned to another, or returned at different time.

1.1 FIGHT CLIMATE CHANGE

STATUS QUO

- Our science based targets are in line with a "well below 2°C" scenario and were approved by SBTI in 2023.
- Investments to reduce our scope 1&2 emissions by 25% until 2030 are assessed for technical feasibility, CapEx needs and OpEx effects.
- Supplier engagement program implemented to reduce procured materials scope 3 emissions. Product Carbon Footprint guidelines launched within the Together for Sustainability (TfS) initiative to help suppliers to quantify and reduce carbon footprints.
- CDP Climate Change awarded Evonik a grade of A- in 2023.
- Continuous dialogue with business lines and customers established to increase the understanding of our product impacts and to quantify avoided emissions.

< 2°

Our climate targets have been approved by SBTi in 2023 and are in line with "well below 2° scenario"

FIELDS OF ACTIONS & AMBITIONS

- Update and further evolve project pipeline for CapEx needs, abatement cost, business case assumptions, execution status.
- Better understand costs and availability of green raw materials and engage with our suppliers and customers to pass on these costs along the value chain.
- Intensify efforts to secure renewable electricity.
- Intensify dialogue with our customers and partners to avoid emissions along the value chain.

AWARD

CDP Climate Change awarded Evonik a grade of A- in 2023.

CDP DISCLOSER 2023

1.2 DRIVE CIRCULARITY

STATUS QUO

- Around 12% of Evonik raw materials are bio-based.
- Integration and start of Circular Economy assessment framework into PSA in 2023 to analyze early and detailed risks and opportunities for Evonik's portfolio.
- Continued active contribution in WBCSD on circularity topics and PSA.
- In 2023, we expanded the former Global Circular Plastics Program into the Global Circular Economy Program. In this way, we are strengthening the development of our business activities in the direction of a circular economy, covering all of Evonik's business areas.

FIELDS OF ACTIONS & AMBITIONS

- Improve tracking of circular raw materials and understanding for best use for alternative source.
- Combine increased share of circular raw materials with reliable supply.
- Create sufficient supply chain control (e.g. via partnerships or backintegration) for relevant raw materials.
- Increase share of sales with NGS supporting a Circular Economy.

CIRCULAR ECONOMY

We are focussing on enabling circularity with our products and contributing to circular economy in various value chains.

1.3 SAFEGUARD ECOSYSTEMS

STATUS QUO

- Water and biodiversity risks at Evonik sites have been assessed with the WWF Water and Biodiversity Risk Filter.
- Water and biodiversity have a key relevance in the upstream part of our value chain. Water-intensive raw materials and processes have been identified.
- Biodiversity impact at our sites is measured using a set of indicators based on the 5 pressures on biodiversity as defined by the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services)[4].
- Bio-based and recycled raw materials usually have a higher specific blue water consumption than fossil ones, so a higher share of circular inputs will result in an increase of blue water consumption. We use our LCA data to identify potential risks and help businesses and procurement to make the right decisions on the future raw material supply.
- CDP Water Security awarded Evonik a B in 2023.
- Evonik has been an active member of the RSPO since 2010.

AWARD

CDP Water Security awarded Evonik a grade B in 2023.

CDP DISCLOSER 2023

Evonik follows a
WATER STEWARDSHIP APPROACH
to assess its water related risks and opportunities along the value chain

FIELDS OF ACTIONS & AMBITIONS

- Our water stewardship approach comprises raw materials and products. To achieve it, we integrate water topics more systematically into business decision making, we intensify the dialogue with suppliers on water-related topics (e.g. on sourcing regions of purchased raw materials in order to assess potential water scarcity in our supply chain), and, finally increase transparency on water issues.[5]
- Biodiversity also needs to gain importance in supplier dialogue in relevant value chains. Following the LEAP Nature Risk Assessment Approach[6], the location of upstream operations needs to be identified in order to define how these activities interface with ecosystems. Dependencies and impacts can then be evaluated for the identified locations. Finally, material risks and opportunities can be discussed as well as existing mitigation approaches.
- We are developing an approach for evaluating the financial consequences resulting from our water (and biodiversity) risks e.g. due to an increase of water prices or business disruption due to water scarcity.
- Coherent management of greenhouse gas emissions reduction and blue water consumption is needed, especially for the transition towards circular raw materials.
- Some Evonik products enable water savings and/or enhance biodiversity in their applications. This handprint will be further quantified in the near future.

[4] The 5 pressures on biodiversity are: land/freshwater and ocean use change, climate change, direct exploitation, pollution and invasive species.
[5] according to the 6 principles defined by the CEO Water Mandate (https://ceowatermandate.org/)
[6] https://framework.tnfd.global/the-leap-nature-risk-assessment-process/

1.4 ENSURE HEALTH & WELLBEING

STATUS QUO

- We have established a software solution that allows us to link the product stewardship substance data with material data. Information is then consolidated on product and PARC level.
- In the PSA, signal category 1 (SC 1) uses relevant hazard information of the PARC together with the risk assessment of exposure and is the base for scoring.
- Hazard information including anticipated regulatory trends based on the European Chemicals Strategy for Sustainability (CSS) is used for portfolio review of risks, opportunities and follow-up actions.
- Active contribution to WBCSD'S PSA update in 2023 with one focus point being signal categories 1 und 2 on chemical safety. First steps of integration into Evonik's method in 2023.
- Our Health Care business is developing effective medication and treatments for a healthy life that minimize negative environmental impacts.

FIELDS OF ACTIONS & AMBITIONS

- Finalization of PSA update integration on SC 1 and 2.
- Update of software that allows us to link the product stewardship substance data with material data to reflect these changes.
- Further work on consistent data structure and evaluation in consideration of future requirements.
- Better understand the health impact of enabling alternatives and more effective pharma therapies.

HEALTH CARE

Our Health Care business is solutions provider to the pharmaceutical industry and contributes to the reduction of the environmental of medication and treatments.

Evonik sustainability analysis

2

Evonik sustainability analysis

2.1 METHODOLOGY

Our sustainability analysis is closely based on the principles and content of the WBCSD Portfolio Sustainability Assessments (PSA)[7]. The framework for the sustainability analysis comprises the five process steps illustrated on the next page.

The unit of assessment is defined as a so-called product-application-region-combination (PARC). PARCs group combinations of products, applications and regions for which sustainability performance – in terms of both favorable and unfavorable sustainability signals – is similar. Sustainability signals relate to material ecological or social aspects along the value chain, from the supply chain through production and subsequent use to end of life.

The PSA methodology describes the signal categories (SCs) of specific relevance for the chemical industry:

1. Chemical hazard and exposure across the life cycle (SC 1)
2. Global regulatory trends (SC 2)
3. Sustainability ambitions in the value chain (SC 3)
4. Authoritative ecolabels (SC 4)
5. Sustainability performance compared to alternative solutions (SC 5)

Evonik follows this approach and evaluates the signal categories 1 to 5 to determine the sustainability performance of our portfolio.

The findings are used in a structured overall evaluation of the PARC's sustainability performance, resulting in allocation to the performance category:

- A++ (LEADER)
- A+ (DRIVER)
- B (PERFORMER)
- C- (TRANSITIONER)
- C-- (CHALLENGED)

Equal weight is given to all material signals; negative signals are not offset by positive signals.

Together, the categories "Leader" and "Driver" cover the Next Generation Solutions. Results of the PSA are published yearly in the Evonik sustainability report.[8] In 2023, Evonik generates 43% of sales with NGSs.

Our goal is to make NGSs grow beyond 50% by 2030, through existing NGSs, new sales from innovations, and from exiting "Challenged" and "Transitioner" product or replacing them with new formulations.

In the Figure 2, our NGSs are split into the four SFAs and attributed to our markets according to their sales in 2023.

A++ (LEADER)

A++ indicates PARCs that take the lead in meeting the standards for sustainable business defined by Evonik's stakeholders and our impact. PARCs in the A++ category fully meet the requirements. They do not show any material negative signals. Moreover, material strong positive signals have been identified in one or more signal categories.

A+ (DRIVER)

A+ indicates PARCs that are at an advanced stage of meeting the standards for sustainable business set by Evonik's stakeholders and our impact. PARCs in the A+ category meet almost all the requirements. They do not show any material negative signals. Unlike those in the A++ category, however, only material weak positive signals were identified for one or more signal categories.

B (PERFORMER)

B indicates PARCs with a neutral position regarding meeting the standards for sustainable business defined by Evonik's stakeholders and our impact. For PARCs in this category, neither material negative nor material positive signals have been identified.

C- (TRANSITIONER)

C- indicates PARCs that show room for improvement in meeting the standards for sustainable business defined by Evonik's stakeholders and our impact. They do not yet meet these requirements. Material weak negative signals were identified, but no material strong negative ones, for one or more signal categories.

C-- (CHALLENGED)

C-- indicates PARCs that do not satisfactorily apply the standards for sustainable business set by Evonik's stakeholders and our impact. PARCs in the C-- category do not meet these requirements. Moreover, they have material strong negative signals in one or more signal categories.

[7] https://www.wbcsd.org/Programs/Circular-Economy/Resources/Portfolio-Sustainability-Assessment-v2.0
[8] https://corporate.evonik.com/en/investor-relations/reports/cr-reports

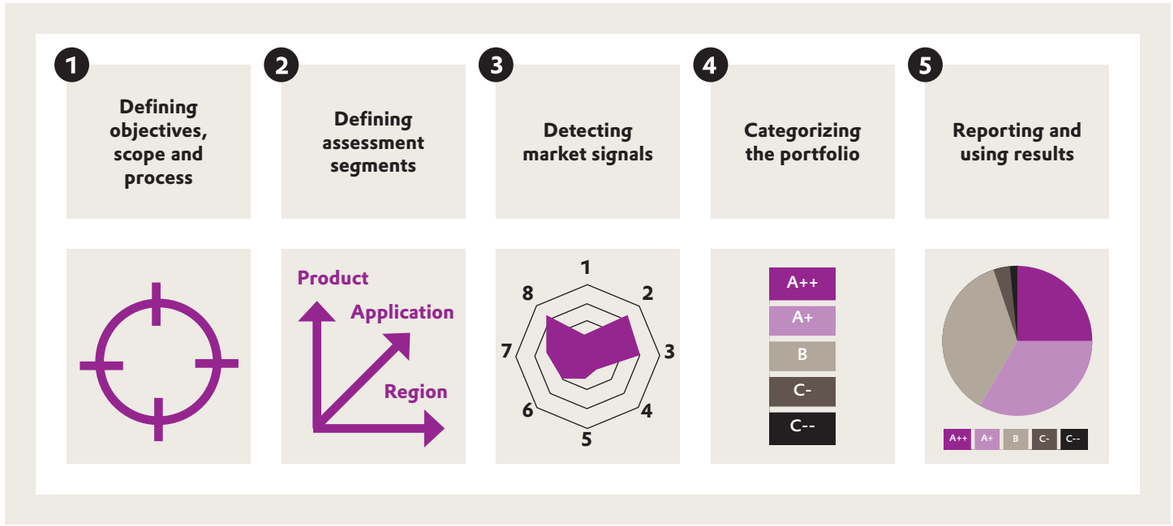


Figure 2
Sales of NGSs split into the four SFAs and markets.

Markets	Impacts: Fight Climate Change	Drive Circularity	Safeguard Ecosystems	Ensure Health & Wellbeing
Renewable energy/transformation	●	●		
Energy efficiency & mobility	●	●	●	●
Green building	●	●		●
Sustainable water/sanitation			●	●
Pollution prevention/waste		●	●	●
Sustainable consumer goods	●	●	●	●
Sustainable agriculture/food	●		●	●
Pharma & medical therapies		●	●	●
Diverse markets	●	●	●	●

● Below 50 M€
● 50 – 200 M€
● Above 200 M€

2.2 CONTRIBUTION OF PARCS TO SFAS

Within the PSA, each PARC is attributed to one of the four SFAs. This choice is determined by which topic is most relevant for the product and its application.

The contribution of the PARC regarding its handprint to the SFA is assessed in SC 5 using the following KPIs:

FIGHT CLIMATE CHANGE

- Avoided greenhouse gas emissions (kg CO_2e)

DRIVE CIRCULARITY

- Avoided waste (kg)
- Avoided resource used (kg)

SAFEGUARD ECOSYSTEMS

- Avoided water consumption (m^3) or reducing water scarcity footprint[9]
- Avoided land use (ha)
- Depending on application, KPIs might still be under development:
  - reduce marine biodiversity,
  - reduce eutrophication,
  - reduce acidification, etc.

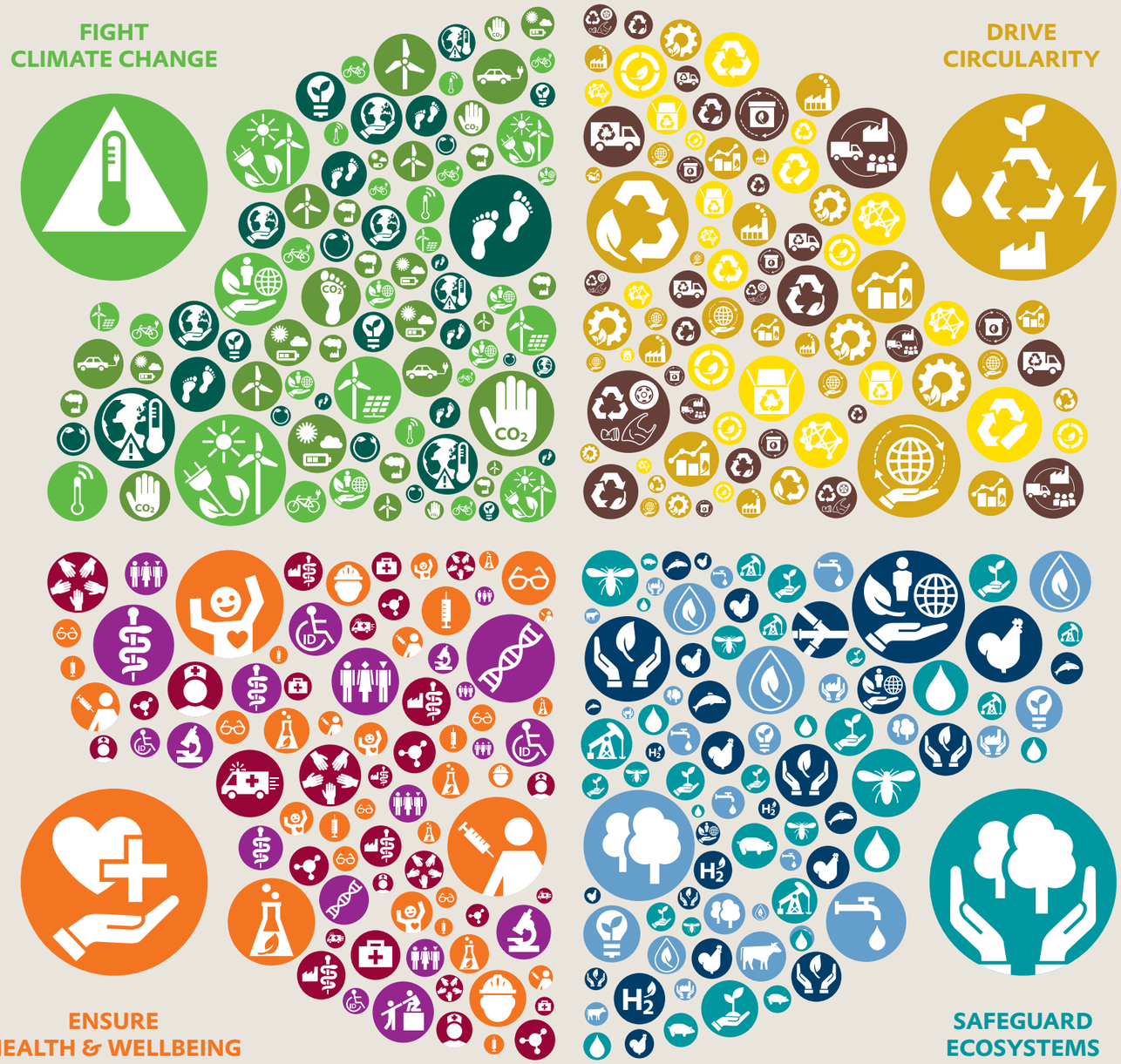
ENSURE HEALTH & WELLBEING

Indicators for handprint are still under development. Those KPIs could describe the following effect:

- Reduce hazard exposure or exposure to disputed chemicals (e.g. VOC, microparticulate matter, disputed chemicals)
- Enabling more efficient therapies

[9] Water scarcity footprint is a indicator of the water consumed weighted with a local water scarcity index i.e. an index that characterize water stress for a specific area and time.

Handprint of selected Evonik's Next Generation Solutions



3

Handprint of selected Evonik's Next Generation Solutions (NGSs) for the four Sustainability Focus Areas

We define handprint as positive sustainability impacts that Evonik products enable along the value chain compared with other established products and applications on the market. Often this positive contribution occurs downstream of Evonik's production processes (i.e. in customer's production processes or during consumer use). These products make a relevant contribution to a direct (measurable) improvement regarding one or more environmental and/or social indicators. This is reflected in a strong or weak positive rating in the PSA's SC 5 (environmental and social performance compared to alternative solutions).

This handprint reflects the material sustainability ambitions addressed in SC 3 that the PARC is delivering on. During the annually conducted PSA, special attention is paid to revising the market reference as it might quickly evolve over time or the Evonik solution might even become the market reference itself (and would consequently have no more handprint as defined for the SC 5).

A handprint can be assessed qualitatively or (semi-) quantitatively (e.g. when the handprint is about a health benefit). Our goal is to increase the number of quantitative analyses, to gain deeper knowledge of our product benefits and transparency.

3.1 METHODOLOGY AND RESULTS OF THE 2023 HANDPRINT EVALUATION

Evonik offers a variety of products having a handprint over their life cycle compared to using conventional alternatives.

We have been reporting avoided greenhouse gas emissions for selected product applications since 2008 following the chemical sector guidance "Avoiding Greenhouse Gas Emissions" published jointly by the World Business Council for Sustainable Development (WBCSD) and the International Council of Chemical Associations (ICCA)[10]. In 2023, we have also extended our avoided emissions approach to another impact category: avoided resource use, that is a relevant topic covered by the SFA Drive Circularity. These calculations have been verified by an external auditor within the scope of our auditors' limited assurance engagement of the sustainability report.

Our approach and rules for evaluating the handprint of our products is extensively described in a methodological paper published alongside this handprint brochure[11]. The internal Evonik Life Cycle Management team works in close cooperation with experts from the responsible business lines and performs life cycle assessments (LCAs) inaccordance with the requirements of DIN EN ISO 14040 ff. Greenhouse gas emission savings (or any other impact KPI used to describe the handprint) are calculated on the basis of the life cycle emissions of applications of selected Evonik products compared to conventional alternatives. Both the emission-saving product and the reference solution must deliver the same function to the user and be used for the same application. Additionally, the reference solution must be available on the market, interchangeable for the typical customer in the selected market, and as similar as possible to the emission saving product in terms of data quality, methodology, and assumptions. The simplified calculation methodology as mentioned in the "Avoiding Greenhouse Gas Emissions" guidelines is applied, so that identical steps and corresponding emissions over the life cycle for the reference and Evonik solution are excluded from assessments. This approach has no impact on the final amount of calculated greenhouse gas emission reductions.

The selected indicators are first calculated for the specific Evonik product application, then for the market reference. The difference in emissions or impact between the Evonik solution and the market reference corresponds to the handprint (per functional unit). Knowing the required amount of the Evonik product in the product application (or per functional unit) to achieve the saving potential, the handprint per kilogram of sold product can be calculated (specific handprint per kg of sold product). Finally, the absolute handprint is multiplied by the overall sales volume of the respective product(s) in the corresponding reporting year to obtain the overall handprint of the product application.

The handprint results for the year 2023 are based on the following 11 Evonik solutions and the following KPIs.

NGSs selected for handprint evaluation	KPIs
Green tire technology	GHG
POLYVEST® in green tire tread compounds	GHG
Hydrogen peroxide to propylene oxide (HPPO) process	GHG
Fumed metal oxides in Lithium-ion batteries	GHG
Amino acids in animal feed	GHG
Improved hydraulic fluids for construction machinery and for stationary equipment	GHG
Additives enabling the use of renewable raw materials for in polyurethane flexible foams	GHG
Easy-to-disperse silica based rheology modifiers for inks and coatings	GHG
Excel® rejuvenation of catalysts	GHG, avoided resource use
Silica for paper	GHG, avoided resource use
Linerless release coating	GHG, avoided resource use

[10] World Business Council for Sustainable Development (WBCSD) and International Council of Chemical Associations (ICCA), Avoiding Greenhouse Gas Emissions-Guidelines: Accounting for and Reporting Greenhouse Gas (GHG) Emissions Avoided along the Value Chain based on Comparative Studies, Version 2, December 2017

[11] https://files.evonik.com/shared-files/avoided-emissions-2022-methodology-9364.pdf

In the section 3.2, selected Next Generation Solutions (NGSs) that enable greenhouse gas emissions savings and/or enable avoiding resources will be described. For the solutions that have already been considered in the previous years to report on avoided emissions, a short description will be provided focusing on the eventual changes made in the scope, assumptions or calculations. For the new examples, a more detailed description of the product application will be provided.

Within the sustainability analysis, it has been checked that the selected PARCs are rated as Next Generation Solutions so that these products do not reveal any negative signals.

In 2023, the use of the eleven selected Evonik Next Generation Solutions results in the avoidance of 48.2 million metric tons CO_2e. Based on three selected Evonik NGSs, the potential for avoiding 378 metric kiloton of resource has also been quantified. These 48.2 million metric tons CO_2e and 378 kiloton of resource reflect the total savings of the selected applications enabled by the amounts of the eleven Evonik solutions sold in 2023.

Each NGS provides a measurable improvement over the life cycle and the associated Evonik products have either a fundamental, extensive, or at least a substantial contribution to reducing greenhouse gas emissions compared to conventional alternatives[12].

A few examples will be also presented related to the SFA Safeguard Ecosystems (Peracetic acid for environmental water treatment and PhytoSquene® for vaccine formulation) and Health & Wellbeing (PhytoChol® a plant-based Cholesterol for drug delivery and cell culture applications) describing the handprint more qualitatively as a full quantification is not yet available.

3.2 SELECTED NEXT GENERATION SOLUTIONS FOR HANDPRINT EVALUATION

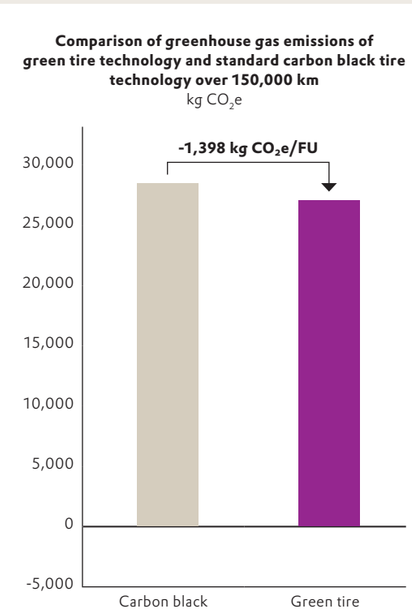
First of all, examples already presented in the previous brochure as product application enabling greenhouse gas savings will be summarized highlighting the eventual changes in comparison to the previous year. For each example, following modifications have been made:

- Update of background data in LCA software
- Update of sales amount to 2023 quantities (the global amount sold of the corresponding Evonik solutions in 2023 was used to calculate the total savings)

[12] The significance contribution of chemical products to value chain avoided emissions is described in the WBCSD "Avoided Emissions" Guideline.

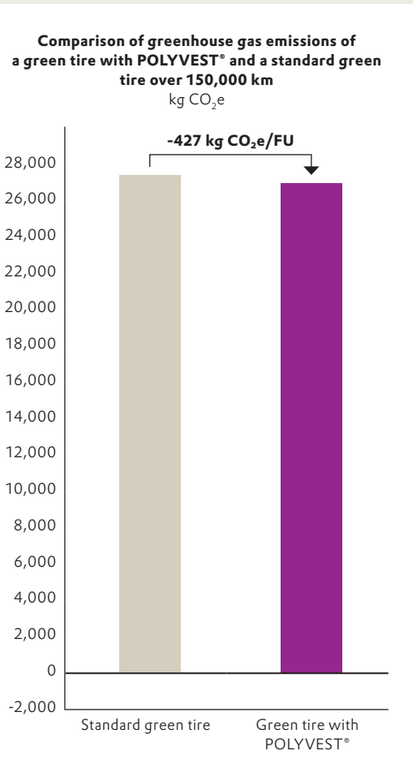
GREEN TIRE TECHNOLOGY

Silica silanes in tires have been described in the previous brochure (▸ page 26 and 27).



Next Generation Solution	Silica-silane systems in a specific rubber blend (S-SBR, BR) as a tread component in region Americas/East Europe & Turkey/Asia without Japan & South Korea for the green tire technology.
Reference solution(s)	Carbon black tire: Carbon black as filler material and emulsion styrene butadiene rubber (E-SBR) as tread component.
Functional unit	The use of silica-silane and rubber compound (S-SBR, BR) or carbon black and E-SBR as components in a compact car tire over 150,000 km.
Boundaries	Cradle-to-grave. Life cycle steps considered in calculations are shown in the previous brochure.
Main parameters and assumptions	The respectively required volumes of tread components for the distance of 150,000 km have been determined. A passenger car EURO 6 with its corresponding fuel consumption was assumed. Same type of vehicle and tires in each region. Field test data and statistics on fuel consumption and savings were considered.
Background information on the assessment	The life cycle assessment was completed and certified in 2015. In 2022 the LCA for the Silica production was updated using 2021 production data. With the recent update, the differentiation and regionalization between different Silica grades was increased. Each Silica grade which is used for the green tire technology is now covered by a site/region specific LCA. This means that we now use several different Silica LCAs depending on the region where the green tires compete against the carbon black tires and the grades which are typically used in the region.

POLYVEST® IN GREEN TIRE TREAD COMPOUNDS



Polyvest® in tires have been described in the previous brochure (▸ page 34 and 35).

Next Generation Solution	POLYVEST® ST-E 60 as additive for green tire treads.
Reference solution(s)	Standard green tire (silica/silane system in rubber blend).
Functional unit	150,000 km driven by compact car.
Boundaries	Cradle-to-grave. Life cycle steps considered in calculations are shown in the previous brochure.
Main parameters and assumptions	Euro 6 car compact class consuming E10 fuel. Lifetime of 50,000 km for all tire types. Compound formulations for tire treads (expert interview). 1.5% fuel savings by POLYVEST® green tire technology (field test data).
Background information on the assessment	The product LCAs for POLYVEST® HT and POLYVEST® ST-E 60 have been performed in 2022 with 2021 production data. Based on compound formulations from our experts, the required amount of product for the tire treads has been determined. For tire production and end-of-life, the existing green tire model has been used. The use phase has been modeled according to the existing model with additional data on fuel savings by POLYVEST®.

HYDROGEN PEROXIDE TO PROPYLENE OXIDE (HPPO) PROCESS

The HPPO process has been described in the previous brochure (▸ page 32 and 33). A few modifications have been realized which are summarized in the following table:

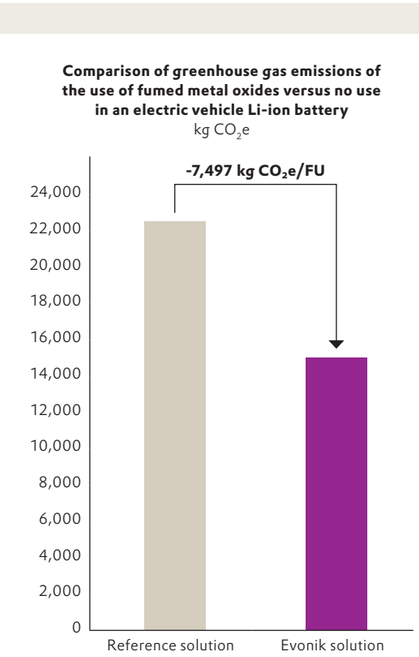
Propylene oxide from the HPPO process shows a by average 24% reduced carbon footprint compared to the average of reference solutions. Depending on the boundary conditions the reduction potential range varies from 15% to 38%.

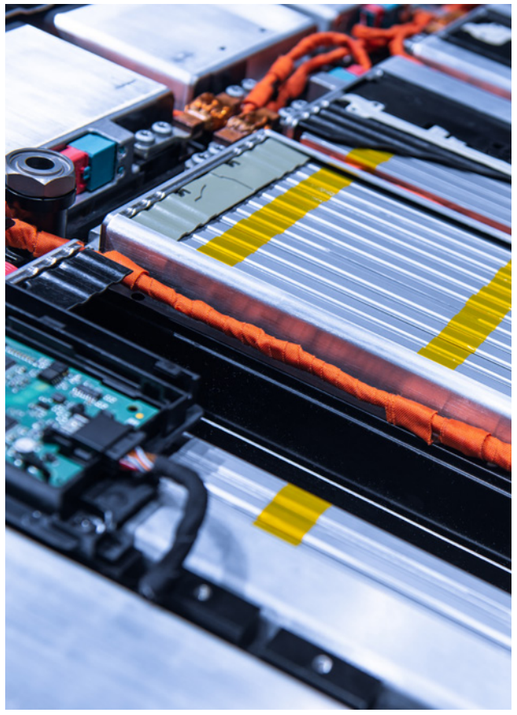
Next Generation Solution	HPPO process for environmentally friendly propylene oxide (PO) production as raw material for different polyurethane (PU) applications.
Reference solution(s)	Conventional processes for PO production as raw material for different PU applications.
Functional unit	Production of one ton of propylene oxide (which can e.g. be processed to polyether polyols and used as PU foam in insulation materials).
Boundaries	Cradle-to-grave. Life cycle steps considered in calculations are shown in in the previous brochure.
Main parameters and assumptions	The cases of South Korea and China have been analyzed separately. The propylene oxide/styrene monomer (PO/SM) and cumene (CuPO) process are considered as competitive routes in South Korea according to their production shares while for China, the chlorohydrin process and the propylene oxide/styrene monomer (PO/SM) according to their production shares are considered as reference to be substituted.
Background information on the assessment	Comparative life cycle assessments have been performed with license agreement data and market report data in 2020. The 2023 sales volume of H_2O_2 to the HPPO production sites and corresponding production amounts of PO have been considered for calculating total savings.

FUMED METAL OXIDES IN LITHIUM-ION BATTERIES

Fumed metal oxides in Lithium-ion batteries have been described in the previous brochure (▸ page 36 and 37).

Modifications have been realized which are summarized in the following table:





Next Generation Solution	AEROXIDE® fumed metal oxides increase the performance, service life and safety of batteries.
Reference solution(s)	Standard electric vehicle Li-ion battery without the use of fumed metal oxides as protective cathode coating.
Functional unit	Electric vehicle Li-ion battery with a capacity of 100 kWh.
Boundaries	Cradle-to-grave. Life cycle steps considered in calculations are shown in in the previous brochure.
Main parameters and assumptions	Literature value for greenhouse gas emissions of battery production has been used. A battery capacity of 100 kWh has been assumed. The Evonik solution increases the battery lifetime by 50%.
Background information on the assessment	The underlying life cycle assessments of the Evonik products have been conducted in 2022 and are based on production data from 2021. The LCA covers the global production of fumed metal oxides with separate LCAs for each production site.

AMINO ACIDS IN ANIMAL FEED

Animal feed is specifically formulated to meet the physiological and nutritional needs of animals, and in particular the necessary requirements of essential amino acids. A 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. Supplementing animal feed with essential amino acids allows for the substitution of high-protein ingredients which are associated with high emissions and requirements on land and water resources.

Furthermore, feed supplementation with these essential amino acids reduces the crude protein content of the diet. Hence nitrogen emissions such as ammonia and nitrous oxide resulting from the manure management are diminished.

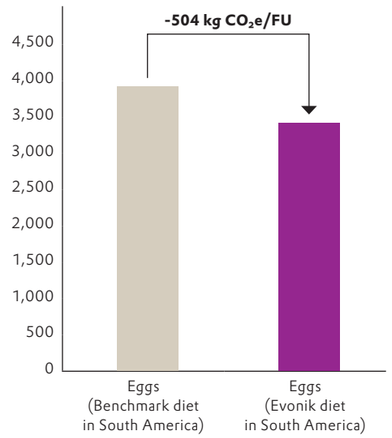
In the Animal Nutrition business line, several PARCs have been created in relation to feed additives (MetAMINO®, Biolys®, and ThreAMINO®) and the sales region. The PARCs relating to the amino acid usage in the regions South America, North Asia, and South Asia and have been rated as NGSs.

A material topic for the agriculture value chain is the protection of the ecosystems. Feed supplements enable a reduction of the amount of feed needed to supply the essential nutrients that animals require and consequently a reduction in land, fertilizer and freshwater use to produce animals. By satisfying the protein requirements of the animals via amino acids, the nitrogen content of the feed diet is decreased, this also reduces the amount of nitrogen excreted by the animals in manure, which helps to reduce harmful nutrient pollution. These two effects contribute to a positive rating in SC 3 and 5 making the amino acids an NGS.

The handprint has been validated by a life cycle assessment and certified by TÜV Rheinland. The functional unit is one ton animal live weight, respective eggs. For example, compared to the industry standard diet, the use of Evonik-recommended amino acid supplementation in layer hen feed can reduce the eutrophication potential of egg production in South America by 12% and in China by 18%.

The visual below shows the carbon footprint of eggs produced via two different diets. Whereas the benchmark diet represents a reference diet in South America with a reduced amino acid content, the Evonik diet contains the amino acid profile recommended by Evonik experts. The amino acid addition in the Evonik diet enables a low-crude protein diet and the reduction of ingredients with a high carbon footprint.

Comparison of greenhouse gas emissions of eggs produced in South America using a benchmark diet and a diet recommended by Evonik
kg CO_2e



Next Generation Solution	Feed mix with a balanced amino acid profile based on Evonik recommendations (including MetAMINO®, Biolys®, and ThreAMINO®), representing "best practice" for diets with low protein levels. In South America, North Asia, and South Asia the application of these amino acids has been rated as Next Generation Solution.
Reference solution(s)	Feed mix with an amino acid supplementation customary in the respective regional market. Such a feed mix usually contains less, and different, amino acid supplementation.
Functional unit	The functional unit and the reference flow have been defined as one ton of live weight or, in the case of feeding laying hens, one ton of eggs.
Boundaries	Cradle-to-grave. Life cycle steps considered in calculations are shown in in the previous brochure.
Main parameters and assumptions	The composition of the feed mixes and the animals' nutritional demands per functional unit relate to 2019. Feeding of pigs, broilers and laying hens has been covered in the study. The composition of the feed mixes, the animals' nutritional demand and (as far as possible concerning data availability) the regional origin of feed materials has been adapted to the regions South America, North Asia and South Asia, respectively. As a conservative assumption, an identical feed conversion rate between the Evonik solution and reference solution (per region) has been considered.
Background information on the assessment	Sales volumes for amino acids supplied by Evonik to the feed industry in 2023 have been used to calculate total savings . Regional sales volumes have been aligned with the respective regional emission avoidance. The considered amino acids are: MetAMINO®, Biolys®, and ThreAMINO®.

IMPROVED HYDRAULIC FLUIDS FOR CONSTRUCTION MACHINERY AND FOR STATIONARY EQUIPMENT

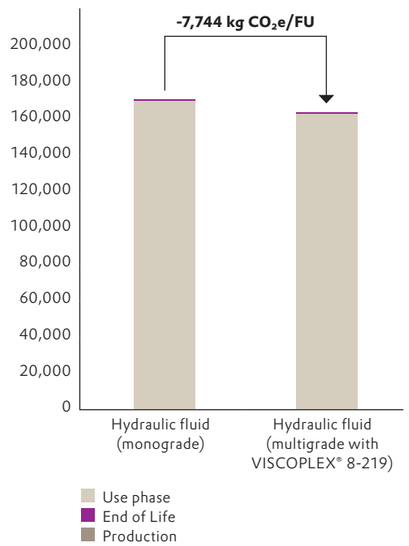
Improved hydraulic fluids for construction machinery have been described in the previous brochure (▸ page 30 and 31).

The handprint for a new application (stationary equipment) was also quantified. In hydraulic manufacturing systems, the operating conditions can vary from highly dynamic to less dynamic flow patterns of the hydraulic fluid. In all cases, the fluid not only needs to protect the equipment from wear and corrosion, but needs to transmit power efficiently, as well.

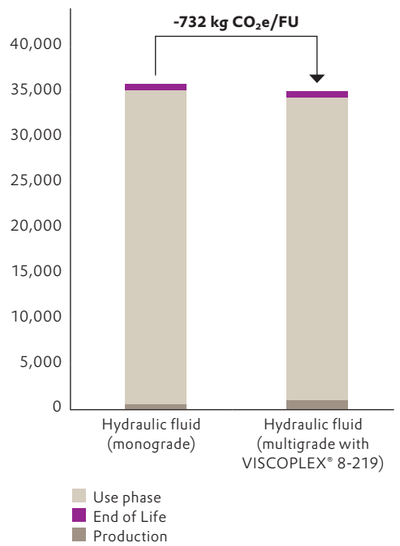
The right oil viscosity under operating conditions in hydraulic pumps, motors, and actuators is crucial for high equipment efficiency. Hydraulic fluids formulated with DYNAVIS® technology are based on highly shear stable viscosity index improvers, VISCOPLEX® from Evonik, that allow fluids to maintain the desired viscosity under shear and over an extended temperature operating window. This technology results in more powerful machinery with reduced internal leakage, less hydrodynamic friction and reduced cooling demand. Lower oil peak temperatures potentially enable longer oil drain intervals.

In the PSA, this product application has been considered within the PARC "Viscosity modifiers for hydraulic fluids in manufacturing" and rated as an NGS because it positively addresses stakeholders' ambitions (SC 3) regarding productivity and energy efficiency. It also has a positive environmental impact (SC 5) compared to conventional hydraulic oils without DYNAVIS® technology (i.e., monograde fluids). Intensive R&D and numerous field trials have proven that DYNAVIS® technology allows manufacturing systems to work up to 10% more efficiently. For example, plastic injection molding equipment benefits with 2–6% reduced energy consumption in the hydraulic system and overall lower GHG emissions. The handprint has been quantified through an LCA conducted by our in-house experts from the LCM group. Using a better oil, based on DYNAVIS® technology at the next scheduled maintenance, is an easy option for reducing energy demand in any hydraulic manufacturing plant.

Comparison of greenhouse gas emissions of DYNAVIS® technology and conventional hydraulic fluids (monograde) in mobile construction machinery.
kg CO_2e



Comparison of greenhouse gas emissions of DYNAVIS® technology and conventional hydraulic fluids (monograde) in stationary hydraulic manufacturing systems.
kg CO_2e

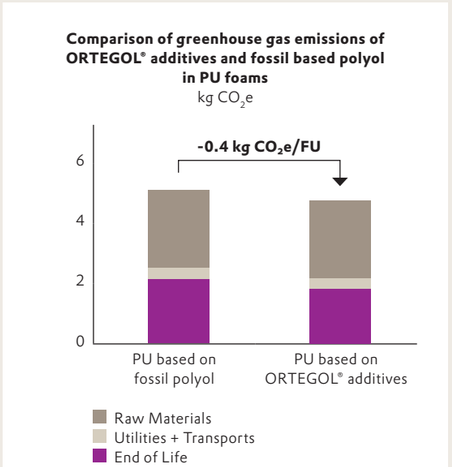


Next Generation Solution	*First case:* DYNAVIS® technology in hydraulic fluids of hydraulic construction machinery globally. *Second case:* DYNAVIS® technology in hydraulic fluids of hydraulic manufacturing systems.
Reference solution(s)	*For both cases:* Conventional hydraulic oils without DYNAVIS® technology (monograde).
Functional unit	*First case:* Operation of a hydraulic construction machine moving 1 million metric tons of mass over a defined distance. *Second case:* 8000 h production hours of an injection molding machine.
Boundaries	*For both cases:* Cradle-to-grave. Life cycle steps considered in calculations are shown in the previous brochure. Identical emissions for Evonik and reference solution are not considered, e.g., those caused during production of excavator or injection molding machinery.
Main parameters and assumptions	*First case:* All hydraulic fluids have been used in field tests in a mid-sized excavator. While the oil drain interval of the monograde fluid is 2,000 hours, the DYNAVIS® fluids need to be changed after extended oil drain intervals, i.e., 4,500 hours. Furthermore, fuel consumption per functional unit decreases by 5–15%. *Second case:* Based on the latest field tests, 3.3% electricity saving was found. Total amount of reduction mainly depends on the length of the cycle. Oil Drain Interval (ODI) of 8000 h. For the carbon footprint of the monograde fluid, composition is assumed to consist of 100% base oil group I.
Background information on the assessment	*For both cases:* The model is mainly based on data from Europe. The reference year is 2022. Savings refer to the global use of DYNAVIS® technology. The global amount sold of the corresponding Evonik VISCOPLEX® products to the hydraulic oil industry in 2023 has been used to calculate total savings.

ADDITIVES ENABLING THE USE OF RENEWABLE RAW MATERIALS IN POLYURETHANE FLEXIBLE FOAMS

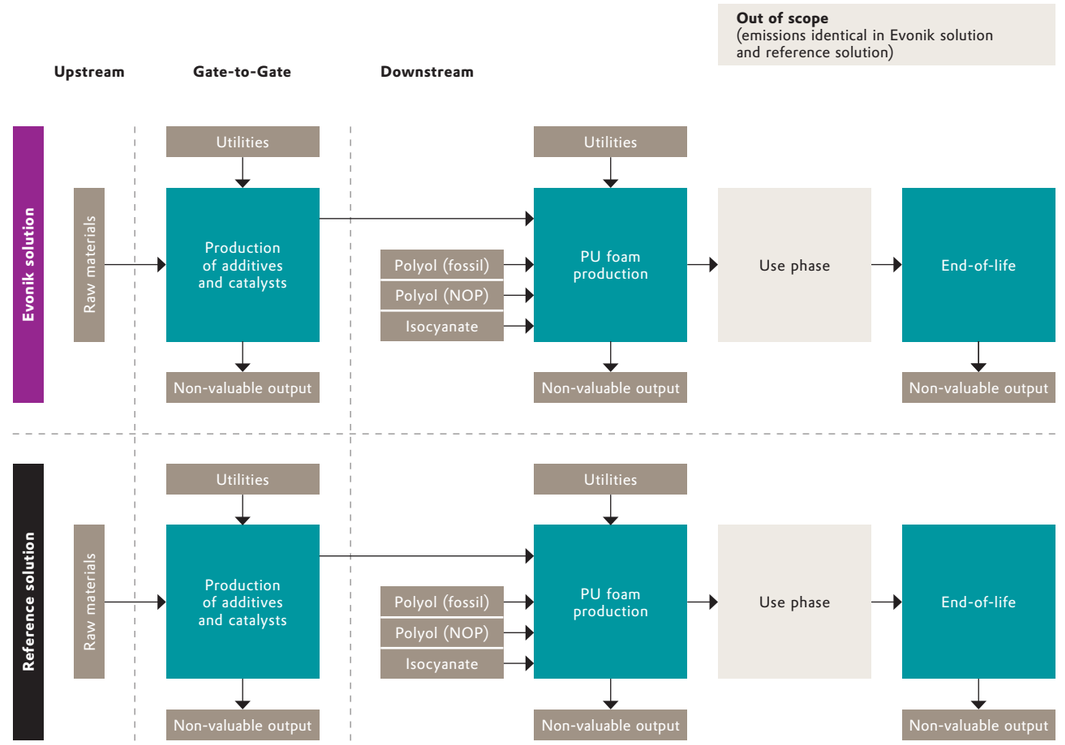
Flexible polyurethane foam is used in various applications, throughout our daily lives, from mattresses, to car seats or kitchen sponges. Polyurethane (PU) foam is made out of two main raw materials, namely isocyanate and polyol. Natural oil-based polyols (NOPs) are a type of polyols derived from vegetable oils, such as castor, rapeseed, or soybean oil. NOPs are considered as renewable and sustainable alternatives to fossil-based polyols produced from ethylene oxide and propylene oxide. In our example, fossil-based polyether polyol can be replaced by alkoxylated castor oil in flexible PU foam applications. Typically, the amount of NOP that can replace fossil-based polyol is limited without compromising mechanical properties of the foam. The ORTEGOL® additives from Evonik enable the use of higher shares of NOP in foam formulations, without compromising foam performance. Thanks to these additives, flexible PU foams with increased renewable carbon content and reduced greenhouse gas emissions can be manufactured.

The related PARC is rated as an NGS as it fulfills stakeholders' ambitions regarding renewable carbon content increase and lower greenhouse gas emissions (SC 3) in flexible PU foam applications. The positive environmental impact (SC 5) has been confirmed by a cradle-to-grave LCA, performed by our in-house experts. In our analysis we compared a standard foam formulation based on fossil polyols and 20 parts NOP polyol with a 70 parts NOP based foam that included ORTEGOL® additives. The functional unit is 1 kg of flexible PU foam. The analysis shows that the use of small amounts of ORTEGOL® additives enable a reduction of greenhouse gas emissions of 0.4 kg CO_2e/kg FU (i.e. 8%) in the final foam.



Next Generation Solution	ORTEGOL® additives enabling high quality polyurethane (PU) foams based on natural oil polyols (NOPs).
Reference solution(s)	PU foam based on fossil polyol.
Functional unit	1 kg of flexible PU foam.
Boundaries	Cradle-to-grave (Figure 4).
Main parameters and assumptions	GWP excl. bio. C: Advantage of bio-based materials in end-of-life phase. The NOP used is alkoxylated castor oil. For the reference solution, up to 20 parts of NOP can be added without further additives.
Background information on the assessment	For materials produced by Evonik, activity data from the years 2020-2023 and site-specific emission factors for energy are used. Further materials and life cycle stages are modelled according to literature and assumptions. Country-specific datasets for raw materials are used.

Figure 4
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reduction through the use of ORTEGOL® additives in polyurethane foams

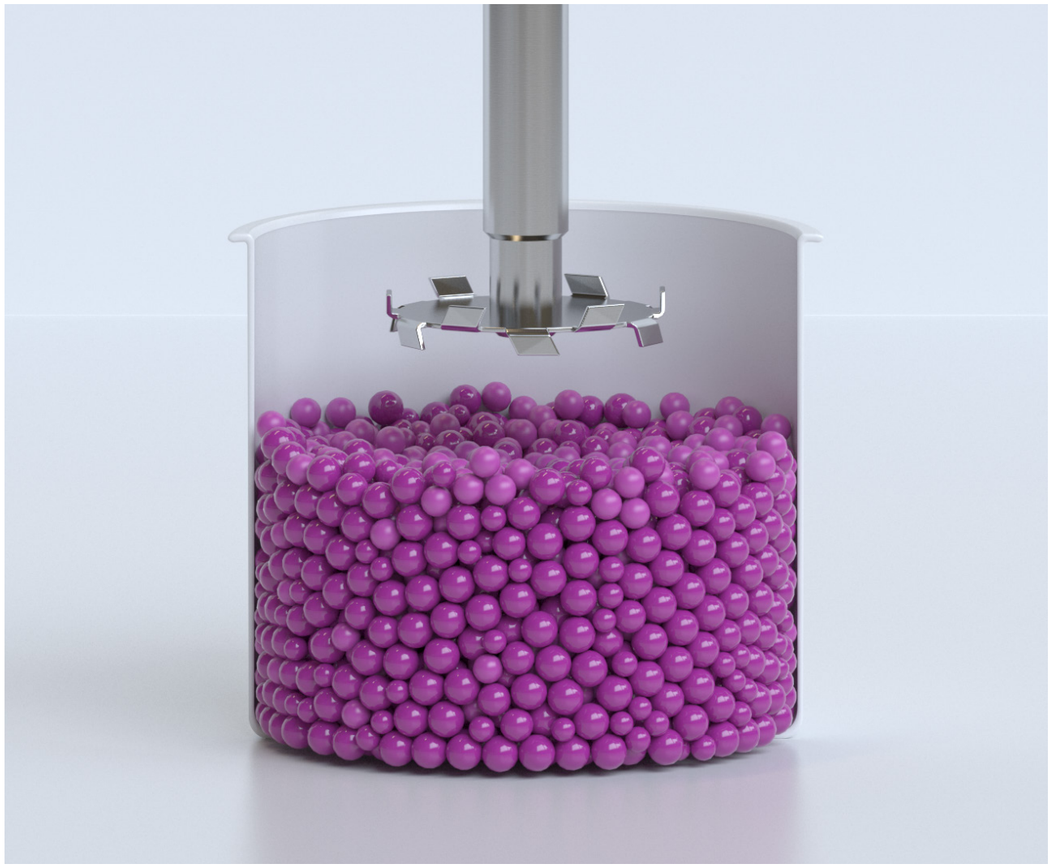


EASY-TO-DISPERSE SILICA BASED RHEOLOGY MODIFIERS FOR INKS AND COATINGS

Fumed silica is commonly used as a rheology modifier in coatings and printing inks to control the flow and viscosity of the coating material. They are added in small amounts, typically less than 3% by weight, and dispersed into the coating matrix using high shear mixing equipment such as bead mills to break up the agglomerates of fumed silica particles and disperse them into the coating matrix.
To properly disperse the fumed silica, the entire formulation must be ground. The dispersion process of fumed silica in coatings is a critical step to ensure that the silica particles are uniformly distributed throughout the coating matrix and is a time-consuming and energy-intensive step in the formulation.

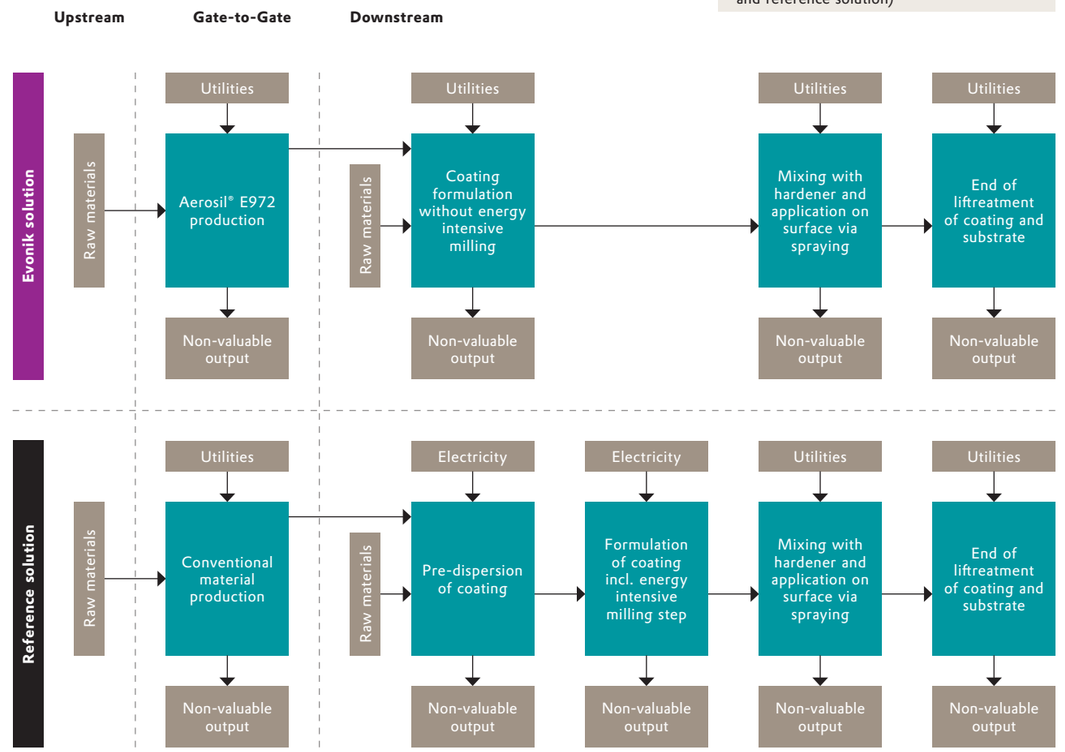
With AEROSIL® E products, Evonik has developed a range of easy-to-disperse fumed silicas. The products are manufactured using a novel production process. The rheological properties of both product groups are the same, but the new AEROSIL® E products are much easier to disperse. This easier dispersion of the additives reduces processing times, energy consumption in production, and the amount of labor and materials required for machine maintenance and cleaning. Processes become more efficient and sustainable.

The positive environmental impact (SC 5) has been confirmed by a cradle-to-gate LCA, performed by our in-house experts. In the analysis, a coating formulation with AEROSIL® E grades was compared with a coating formulation with standard fumed silicas as rheology modifiers. The use of AEROSIL® E fumed silica, especially in the production of clearcoats, can reduce electricity consumption and associated greenhouse gas emissions by up to 75% compared to standard fumed silica. Due to their strong impact on energy reduction, AEROSIL® E fumed silica grades have a strong handprint and are classified as a NGS.



Next Generation Solution	AEROSIL® E grades, enabling the formulation of coatings and inks without the need for high energy consuming bead mill step.
Reference solution(s)	Coating formulation containing standard fumed silicas as rheology modifier, which do not have easy-to-disperse properties.
Functional unit	1 kg of a formulated coating with fumed silica as rheology modifier.
Boundaries	Cradle-to-Gate (Figure 5).
Main parameters and assumptions	GWP incl. biogenic carbon: Advantage of easy-to-disperse silica in formulation step. The extra energy for the production of the easy-to-disperse silica is significantly outperformed by the savings in the formulation step. For the reference solution, the use if a high shear force equipment for the dispersion is mandatory.
Background information on the assessment	For materials produced by Evonik, activity data from the years 2020–2023 and site-specific emission factors for energy are used. Further materials and life cycle stages are modelled according to literature and assumptions. Country-specific datasets for raw materials are used. The datasets for the critical formulation step are based on real life tests in a coating production environment, carried out by RD&I/AT groups.

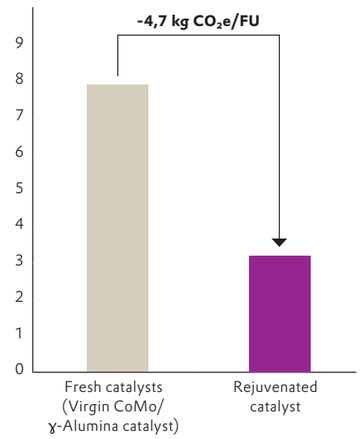
Figure 5
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reduction through the use of AEROSIL® E grades as rheology modifiers

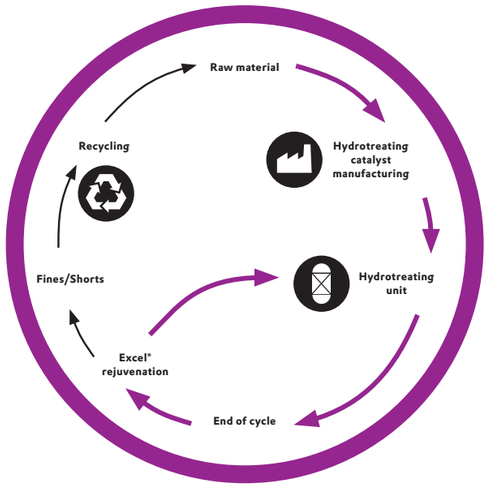


EXCEL® REJUVENATION OF CATALYSTS

Evonik's Excel® rejuvenation process is a step beyond regeneration. It offers a means for restoring spent catalyst and gives refiners an excellent alternative to fresh catalyst in a wide range of hydrotreating applications from naphtha to heavy gas oil. Prior to the rejuvenation step, the spent catalyst is regenerated under oxidative atmosphere to remove both coke and sulfur. Then a chemical treatment is carried out to remove activity inhibitors, redisperse metals and restore active sites for maximum activity. The Excel® technology rejuvenates catalysts and consequently helps avoiding wastes and reducing the CO_2 emissions compared to a fresh catalyst production for refiners (lower use of virgin raw materials and lower energy consumption for processing). Thus, it makes an active contribution to circular economy by maximizing catalyst reuse and minimizing catalysts wastes. In the PSA, the PARC "Hydrotreating regeneration/rejuvenation" is rated as an NGS as it addresses stakeholders' ambitions (SC 3) regarding the commitments in greenhouse gases emissions and wastes reductions. Indeed, clear commitments have recently been forthcoming from our refining customers regarding reductions in Scope 1 and 2 emissions, sometimes including Scope 3 emissions and waste reduction initiatives. The environmental advantage of the Excel® technology (SC 5) has been confirmed by a cradle-to-gate LCA, performed by our in-house experts and comparing the rejuvenating technology with current market reference (i.e. virgin catalyst). The functional unit is 1 kg of rejuvenated catalyst, functionally equivalent to virgin catalyst. The analysis shows that the Evonik technology enables a reduction of greenhouse gas emissions and wastes by about 60% thanks to the rejuvenation technology. For every ton of Excel® rejuvenation of catalysts sales, approximately 900 kg of virgin resource is saved since spent catalyst is recovered and reused.

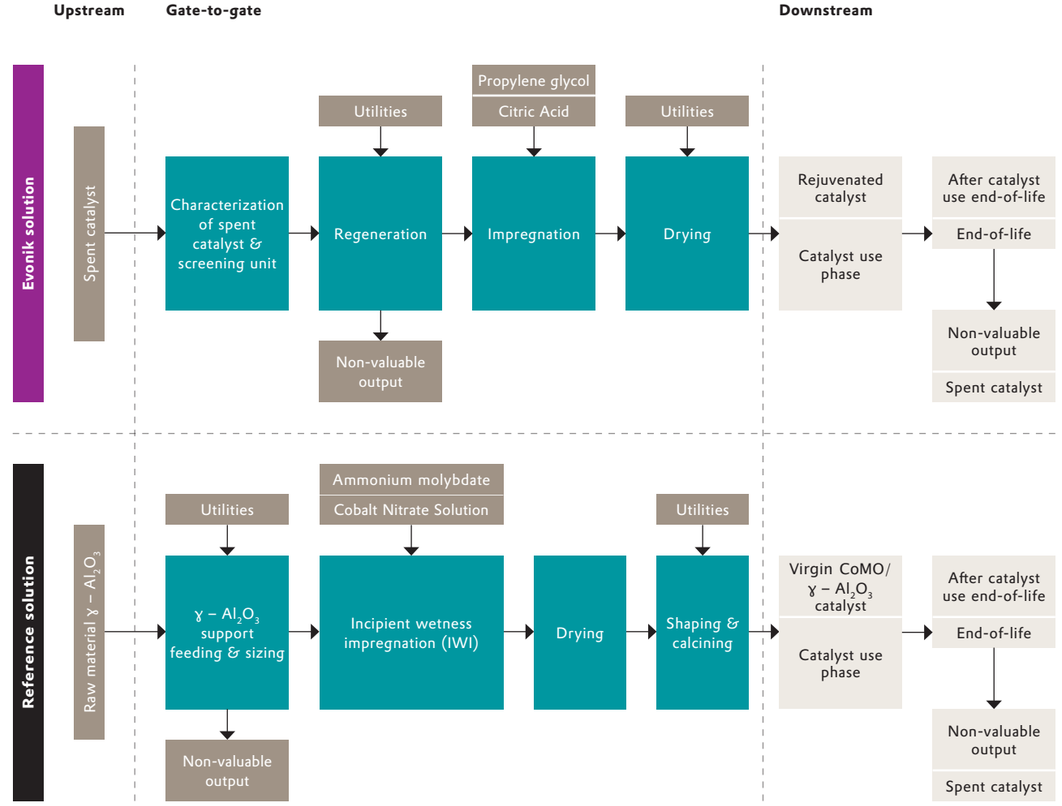
Comparison of greenhouse gas emissions of Excel rejuvenated catalyse and fresh catalyst
kg CO_2e





Next Generation Solution	Excel® rejuvenated catalyst enables to retain the spent catalyst from the hydrotreating processes.
Reference solution(s)	Conventional CoMo/ɣ-Alumina fresh catalyst.
Functional unit	Production of 1 kg of Excel® rejuvenated catalyst from spent catalyst.
Boundaries	Cradle-to-grave (Figure 6).
Main parameters and assumptions	Excel® rejuvenated catalyst follows a simple production process of decoking and cleaning of spent catalyst. The incoming spent catalyst from the hydrotreating plants is environmentally burden free since it is a waste. The spent catalyst is first regenerated, then the regenerated catalyst is fed to rejuvenation process. For comparison, secondary data of fresh CoMo/ɣ-Alumina catalyst production process is used.
Background information on the assessment	Average of 3 years (2019–2021) of production data is used for this comparative assessment. The utilities, such as, water, electricity, natural gas, are measured values from the production site. Measured flue gases are also used as part of the life cycle inventory.

Figure 6
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions in Excel® rejuvenated catalyst



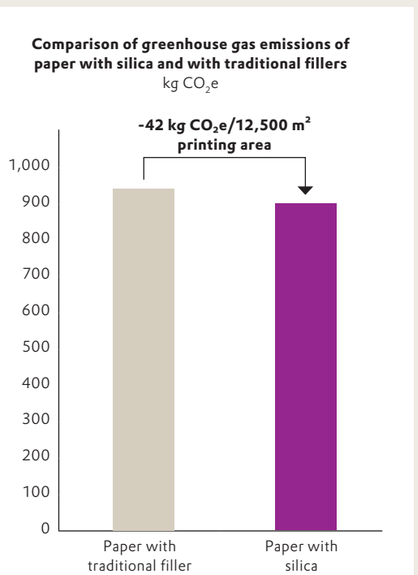
SILICA FOR PAPER

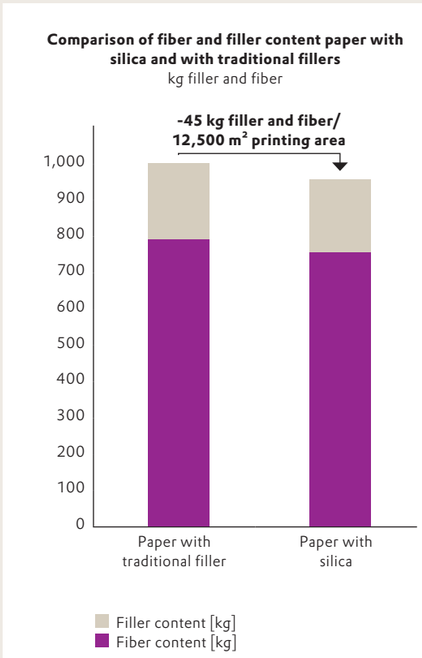
Evonik's Business Line Silica offers a wide product range of precipitated silica and silicate products, fumed silica and fumed silica dispersion materials which are used in paper and board manufacturing applications. HYDREX® P, a silicate-based product, is widely used in different paper and board applications. One of the key product features is that HYDREX® P can support paper and board industry need for lowering energy consumption through lightweighting and the same time improving sustainability. Board lightweighting in the application of white packaging and graphic board has been achieved with low HYDREX® P amount while maintaining optical properties like ISO brightness and opacity. Similar lightweighting is possible in other paper grades where sheet bulk properties are important.

Reduction of energy consumption and environmental impacts have become the important goals for the pulp and paper industry in the current environment. Lightweighting with 2% HYDREX® P supports these goals by offering an option to save at least 5% in energy cost in paper applications. Part of the reduced energy consumption is related to lower steam demand in production where it can be typically reduced by 10 to 20%. Replacing a part of traditional fillers with HYDREX® P improves paper thickness and optical properties which leads to a decrease of fillers and fibers while maintaining the paper thickness and opacity.

If paper brightness is controlled, a further decrease of paper weight is possible.

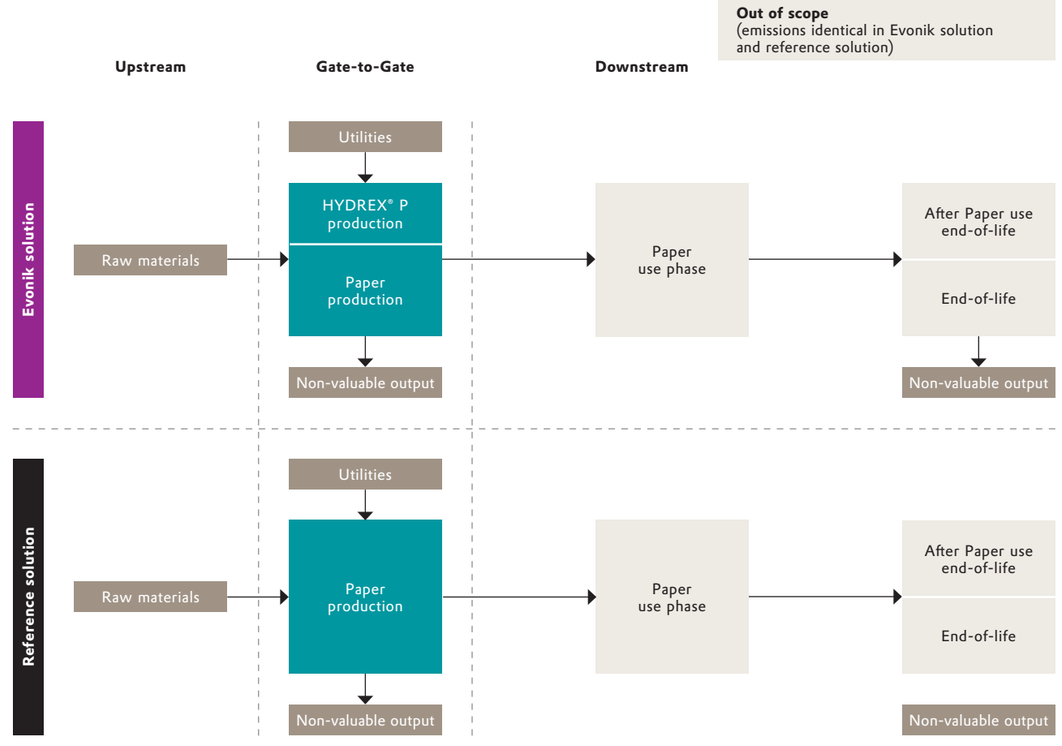
The PARC "Silica for paper" is rated as an NGS as it addresses stakeholders' ambitions (SC 3) regarding to lightweight. The environmental advantage of silica for paper (SC5) has been confirmed by a cradle-to-grave LCA, performed by our in-house experts and comparing paper production with silica and paper production with standard filler. The functional unit is a printing area of 12.500 m^2. The analysis shows that silica for paper production enables a reduction of greenhouse gas emissions and resource savings.





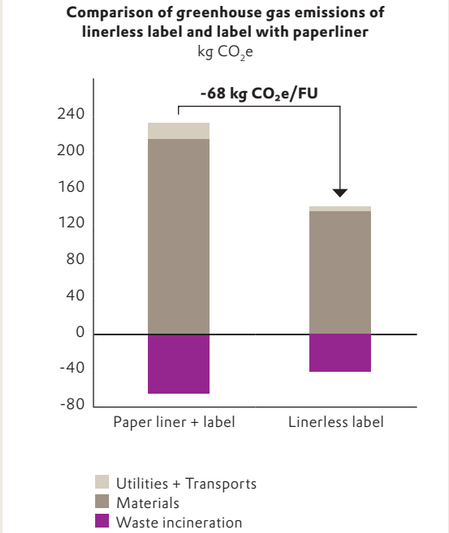
Next Generation Solution	HYDREX® P enables multiple ways to improve paper production sustainability by paper lightweighting.
Reference solution(s)	Paper with traditional fillers.
Functional unit	12,500 m^2 printing area.
Boundaries	Cradle-to-gate: Due to the significant variations of the usage and end of life of paper and therefore would need drastic assumptions, it is not considered in this handprint (Figure 7).
Main parameters and assumptions	The weight of paper with 21% Ash and 0% HYDREX® P is 80 g/m^2. The weight of paper with 19% Ash and 2% HYDREX® P is 76,5 g/m^2. Paper thickness and opacity maintained when decreasing paper grammage. Replacing a part of traditional fillers with HYDREX® P improves paper thickness/bulk and optical properties. Sodium silicate used for HYDREX®P is produced in Finland. For electricity the Finland grid mix was used and thermal energy comes from natural gas.
Background information on the assessment	Time reference is 2021, geographic reference is Hamina, Finland. The reference data used is from 2018 (USA).

Figure 7
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of HYDREX® P in paper



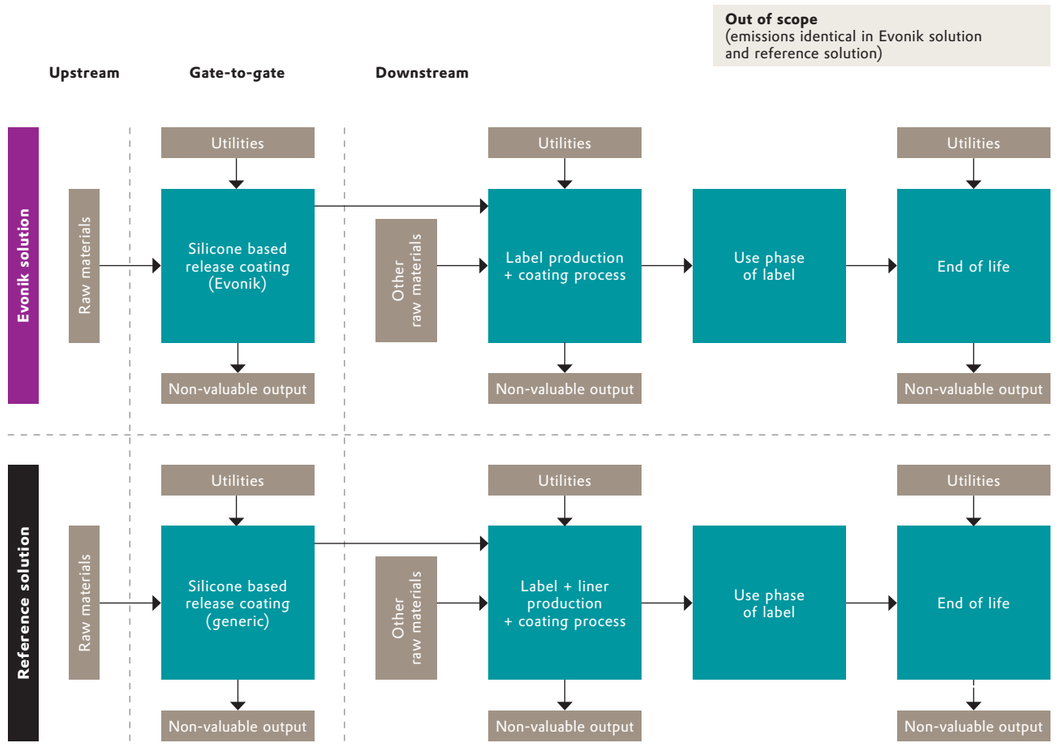
LINERLESS RELEASE COATING

In recent years, interest in linerless labels has increased enormously. Here, the labels no longer stick to a release liner, but are wound directly into a roll, like adhesive tape. A silicone-based release coating ensures that the individual windings separate cleanly, quickly and without any residue before further processing or labelling. The very robust free radical curing mechanism of TEGO® RC silicones can be key to linerless label application on a wide variety of paper and filmic surfaces. Thus, linerless labels are already being used effectively in numerous applications, from health and beauty, food, and beverage to postage and logistics. Linerless labels are especially suitable for use as thermal labels for variable print information. Likewise, prime labels can also be produced. Wrap-around labels in particular are rapidly growing in food packaging. In the self-adhesive label market, the PARC "linerless release coating" is rated as an NGS as it fully addresses stakeholders' ambitions regarding reduced energy and material consumption as well as waste production (SC 3) and has clear environmental benefit compared to conventional self-adhesive labels. Indeed, linerless labels offer clear advantages for the labelling process (more efficient and flexible) and produce less waste and a greenhouse gas reduction in production, logistics and disposal. With conventional self-adhesive labels, the liner accounts for up to 40% of the weight and is therefore also a major driver in the overall cost of materials. After the labelling process, the liner just becomes very expensive waste. With our solution, 29 billion m^2 of release liner waste could be avoided worldwide. Although in the EU about 35% of the total waste of release liner material is fed back into recycling processes, a large part of high-quality and costly cellulose paper still ends up in landfills or incineration, further adding to the waste problem. Linerless labels clearly play a key role in a more circular economy. When using linerless labels, the converter as well as the user do not generate wastes anymore, that they would need to take care of in terms of collecting and disposing or sometimes even paying fees. The handprint has been quantified by a cradle-to-grave LCA, performed by our in-house experts for a functional unit of 1,000 m^2 label. The potential for avoiding waste has also been translated into greenhouse gas emissions avoided along the life cycle: Around 68.5 kg of CO_2e can be saved compared to a standard label, which equates to a saving of 41%.



Next Generation Solution	Reduction of CO_2 through less waste in production, logistics and disposal, as liner material is avoided.
Reference solution(s)	Label with paper liner.
Functional unit	1,000 m^2 label.
Boundaries	Cradle-to-grave (Figure 8).
Main parameters and assumptions	Liner weight 62 g/m^2, Label weight 80 g/m^2, thermal curing for reference solution (liner + adhesive + label), Europe mix for energy and utilities, use phase equal for both solutions, end of life through incineration.
Background information on the assessment	Time reference is 2020 (Evonik data) and 2007 (Reference data from literature and industry). Geographic reference is Europe.

Figure 8
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of linerless labels



Please note

that the following handprint examples have not been quantified by a full LCA.

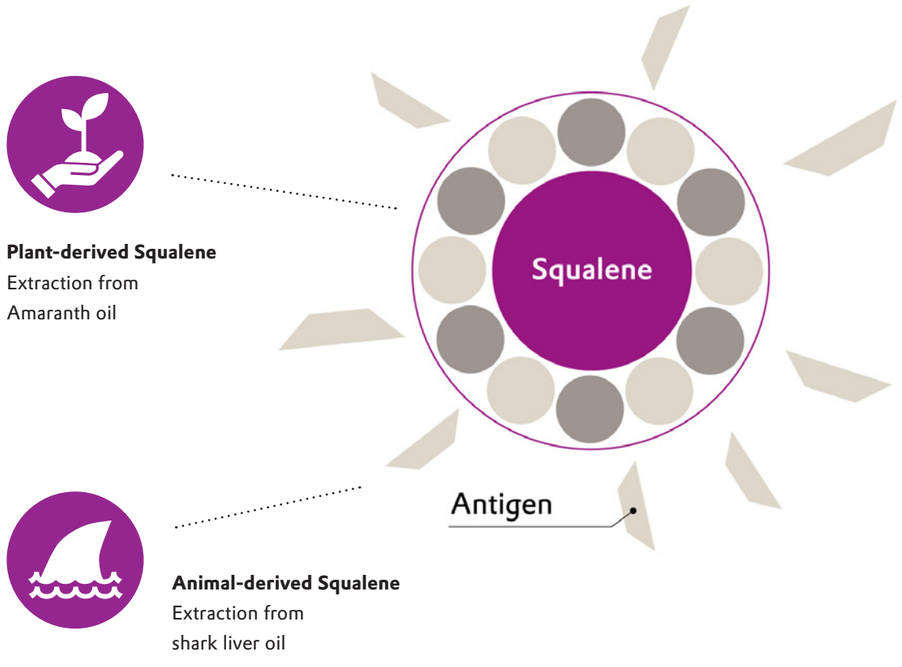
PHYTOSQUENE® FOR VACCINE FORMULATIONS

Each year, 2.7 million sharks from more than 50 different species are caught and killed for their livers. Several of these species are red listed by the International Union for the Conservation of Nature. The liver oil from these sharks is used to extract squalene, and while most of the squalene is used in the cosmetic industry, some is also used in the pharmaceutical industry. In fact, up until now, shark liver has been the only source of pharmaceutical grade squalene. It can take anywhere between 2,500 and 3,000 sharks to extract approximately one ton of the product.

Squalene is an important ingredient in many vaccine formulations. It is used as an adjuvant, which is an additive that boosts the body's immune response to the active ingredient in a vaccine. By improving the effectiveness of a vaccine, adjuvants reduce the amount of active ingredient needed, thereby reducing side effects in patients and allowing a greater number of vaccines to be manufactured.

Evonik offers a more sustainable alternative. A 100% plant-derived product called PhytoSquene®. The product is extracted from the seeds of the amaranth plant and further purified. This new GMP grade of PhytoSquene® has batch-to-batch consistency, and is of the highest quality and purity. It is compliant with European Pharmacopoeia specifications and, being plant based, there is no risk of pathogenic transmission. The benefits of PhytoSquene® are supplemented by Evonik's expertise in formulation and drug product manufacturing in both clinical and commercial applications. PhytoSquene® is also a solution for patients who cannot use animal-derived products for cultural or religious reasons.

PhytoSquene® used in vaccine formulations is rated as a Next Generation Solution for several reasons and contributes directly to the SFA "Safeguard Ecosystems" by reducing the number of sharks killed for the squalene from their livers and by providing an effective plant-based alternative.



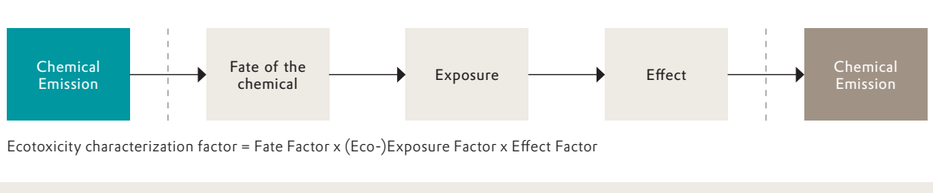
PERACETIC ACID FOR ENVIRONMENTAL WATER TREATMENT

In municipal wastewater treatment, peracetic acid is an ideal choice for the control of pathogenic microbes. Due to its low oxidant demand in wastewater, lack of harmful disinfection by-products, low ecotoxicity, and efficacy, peracetic acid offers a cost-effective alternative to chlorine, UV, and ozone. It is water soluble, can be used across varying temperatures, and remains stable under typical operating conditions.

As a broad-spectrum biocide, peracetic acid has widespread efficacy on a variety of bacteria and microorganisms, even in the presence of organic matter and ammonia. These broad-spectrum properties, combined with its fast action, result in improved efficacy in highly contaminated source and waste waters. Yet there is no buildup of resistance within microorganisms, and as a result no accumulated tolerance.

Peracetic acid for water treatment has been rated as an NGS in the PARC analysis, specifically addressing the SFA "Safeguard Ecosystems". This pertains to its ecotoxicity assessment. Ecotoxicity describes a substance's toxic impacts on the environment. Ecotoxicity models consider fate, exposure, and effects, forming "cause-effect pathways". These factors are used to compute the characterization factor, which can convert emissions into impacts.

Figure 9
Cause-Effect Pathway for ecotoxicity in aquatic environments.



An initial assessment of the ecotoxicity of peracetic acid compared to chlorine-based products in wastewater treatment plants (WWTPs) focused on disinfection steps in an average WWTP in the United States. The study compared the use of Evonik's VIGOROX® WWTII peracetic acid with an equivalent dosage of chlorine, using a functional unit of 1 m^3 of disinfected wastewater. The impact category EF3.1 ecotoxicity freshwater was selected to evaluate effects on the ecosystem. Results showed less ecotoxicity due to the avoidance of disinfection by-products (DBPs) such as TTHM and HAA5. The model is currently being further defined and developed.

PHYTOCHOL® – PLANT-BASED CHOLESTEROL FOR DRUG DELIVERY AND CELL CULTURE APPLICATIONS

Cholesterol Applications in Lipid Nanoparticles (LNP)
Nucleic acid therapies have the potential to treat a variety of conditions from diabetes to HIV, sickle cell disease, and even cancers. However, nucleic acids are fragile active ingredients and must be packaged in a delivery vehicle, such as a lipid nanoparticle (LNP), for safe delivery into the cell. This is where cholesterol plays a critical role.

Cholesterol is one of the four lipids needed to form an LNP or other traditional liposome formulations. It helps improve the encapsulation process, modulates the release of the drug or nucleic acid, enhances the ability to penetrate the cell membrane, and provides stability to the LNP. The precise formulation of LNPs ensures that the RNA is efficiently and stably delivered to a patient's cells.

Typically, cholesterol is extracted from animal products such as sheep's wool, but animal-derived cholesterol has a number of disadvantages, such as batch-to-batch variations in purity and unwanted immunological responses. Companies are increasingly moving away from animal derived cholesterol due to these drawbacks and the additional regulatory measures needed to prevent the risk of disease transmission. Many patients are also looking for non-animal-derived pharmaceuticals for ethical or religious reasons.

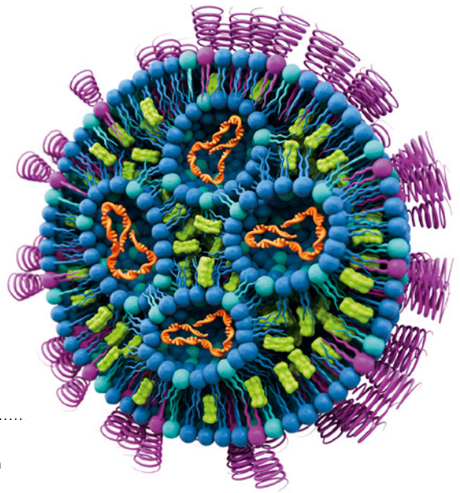
PhytoChol® Inject
Evonik markets the plant-derived cholesterol PhytoChol® Inject for parenteral drug delivery. PhytoChol® is a plant-based product, which allows for high purity and consistency in every batch. This ultra-low endotoxin product also significantly reduces the risk of pathogenic contamination, making it a first-rate alternative to animal-based cholesterol.

Cholesterol Applications in Cell Culture Media
Another very important application of cholesterol is as a component of cell culture media. Typically, fetal bovine serum (FBS) is used in the media, as it provides many of the nutrients needed for the cell lines to grow. However, the use of FBS has its disadvantages: it is animal derived, there are batch-to-batch variations, a risk of endotoxins or other contaminants, and also the ethics of how the serum is collected can be problematic. Nevertheless, cell culture media that do not use FBS often require cholesterol to enhance the growth of the selected cells, protein or virus.

PhytoChol® Biopharma
Evonik offers PhytoChol® BioPharma as a pure powder specifically designed for use in cell culture formulations as an alternative to animal-derived cholesterol. PhytoChol® BioPharma is a highly pure, plant-based cholesterol that can be used in a wide range of cell lines, including the NS0 cell line for the production of therapeutic proteins.

PhytoChol® Inject and PhytoChol® BioPharma are rated as Next Generation Solutions, as they enable very complex and difficult treatments to be developed and also delivered to the patients without the risk of pathogenic contamination.

The PhytoChol® product line is further enhanced by Evonik's expertise in formulation and drug product manufacturing in both clinical and commercial applications.



Nucleic Acid	• The active payload
Ionizable Cationic Lipid	• ~50% • Complexes the nucleic acid • Destabilizes the endosome
PEG Lipid	• ~1.5% • Stabilizes LNPs during formation and controls particle size
Structural Lipid	• ~10% • Examples are DSPC or DOPE • Required for overall stability
Cholesterol	• ~38.5% • Improves stability of LNPs and improves overall encapsulation of payload; affects transfection efficiency

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