# Compilation of information on our Handprint

Quantification of the handprint for selected Next Generation Solutions (avoided emissions, avoided resources)

EVONIK
Leading Beyond Chemistry

# Quantification of the handprint of selected Next Generation Solutions

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 Signal Category (SC) 5 (environmental and social performance compared to alternative solutions) of our Portfolio Sustainability Assessment (PSA).

This handprint reflects the material sustainability ambitions addressed in SC 3 that the PARC (Product Application Region Combination) 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.

## 1. Methodology and results of the handprint evaluation 2024

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)[1]. In 2023, we have also extended our avoided emissions approach to another impact category: avoided resource use, that is a relevant topic regarding 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 compilation of information on our handprint[2]. The internal Evonik Life Cycle Management team works in close cooperation with experts from the responsible business lines and performs life cycle assessments (LCAs) in accordance 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 2024 are based on the following 10 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 |
| ROHACELL® for lightweight materials in airplane | GHG |
| Excel® rejuvenation of catalysts | GHG, avoided resource use |
| Silica for paper | GHG, avoided resource use |
| Linerless release coating | GHG, avoided resource use |

[1] 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

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

# Quantification of the handprint of selected Next Generation Solutions

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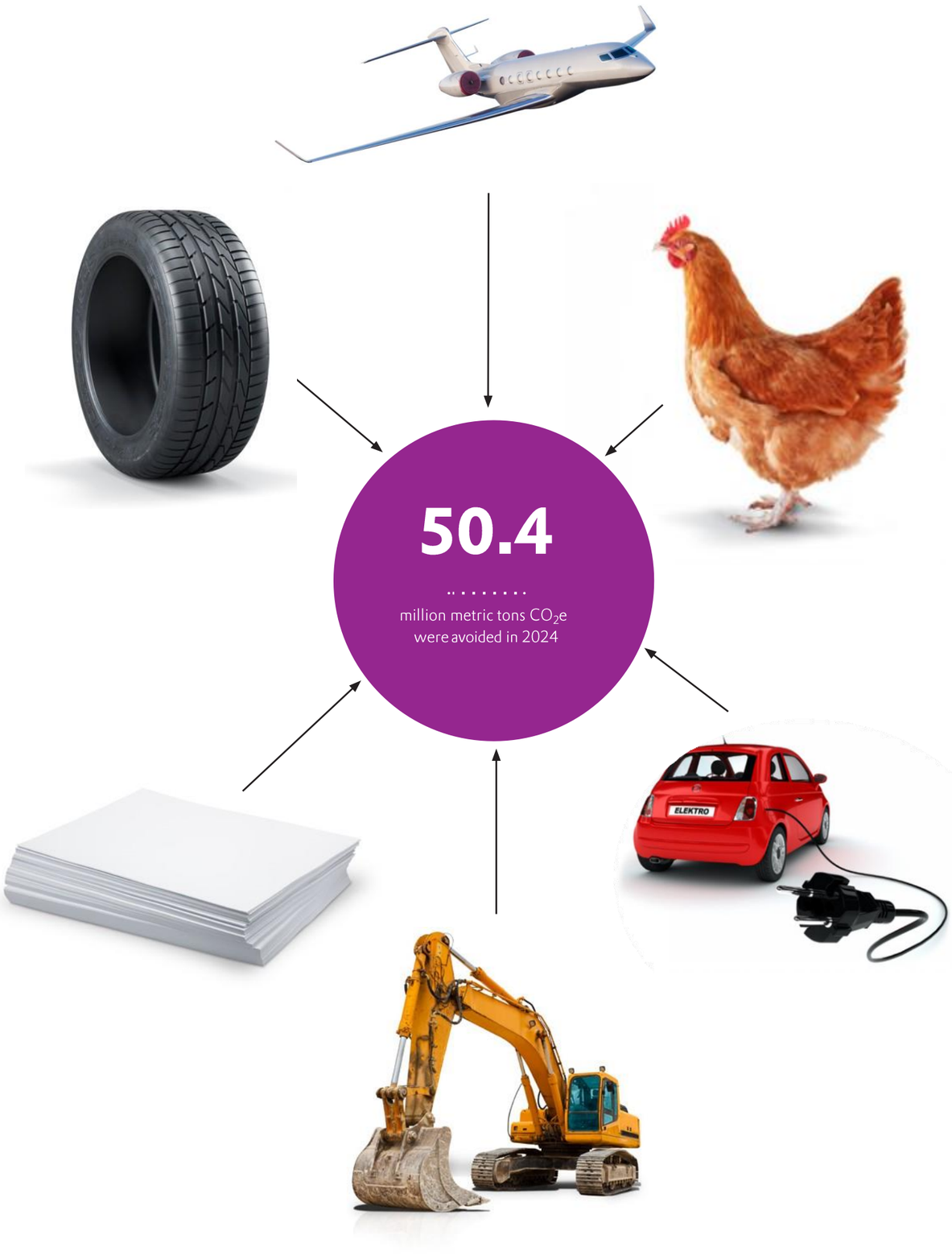



In the section 2, selected Next Generation Solutions (NGSs) that enable greenhouse gas emissions savings and/or enable avoiding resources will be presented. A short description will be provided focusing on the eventual changes made in the scope, assumptions, calculations and results.

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 2024, the use of the ten selected Evonik Next Generation Solutions results in the avoidance of 50.4 million metric tons $CO_2$e. Based on three selected Evonik NGSs, the potential for avoiding 41 metric kiloton of resource has also been quantified.

These 50.4 million metric tons $CO_2$e and 41 kiloton of resource reflect the total savings of the selected applications enabled by the amounts of the eleven Evonik solutions sold in 2024.

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[3].

Besides the quantification of the avoided emissions, we are also engaged to understand and describe our handprint for all our Next Generation Solutions. To illustrate this work, two product applications will be also presented for which we make progress for describing the handprint in the last year.

## 2. Selected Next Generation Solutions for handprint evaluation

Every product application included in the calculation of our greenhouse gas savings will be presented. Following modifications are conducted each year:

- Update of background data in LCA software
- Update of sales amount to 2024 quantities (the global amount sold of the corresponding Evonik solutions in 2024 was used to calculate the total savings).

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

## GREEN TIRE TECHNOLOGY

Evonik's silica/silane system for Green Tires is a Next Generation Solution. Compared to conventional car tires using carbon black as filler, 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 1).

The rubber compounds in tires have a major impact on the characteristics of the 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% reinforcing filler, which is a key ingredient in the rubber compound to reach the desired properties. Instead of carbon black, silica can be used as filler. Bifunctional organic silicon compounds – called organosilanes – serve as coupling agents that connect silica and rubber.

In contrast to conventional carbon black as filler, the use of the silica/silane system allows an expansion of the "magic triangle" of tire performance (see figure 1).

Rolling resistance and wet traction are improved without significantly affecting abrasion and therefore the service life of the tire. These improvements result in significantly lower fuel consumption for end users and therefore in reduced greenhouse gas emissions. Carbon black filled tires still dominate the global market. As the Green Tire technology has penetrated the European and parts of the Asian (Japan and South Korea) market, the advantage is only claimed for the rest of the world where carbon black tires still prevail.

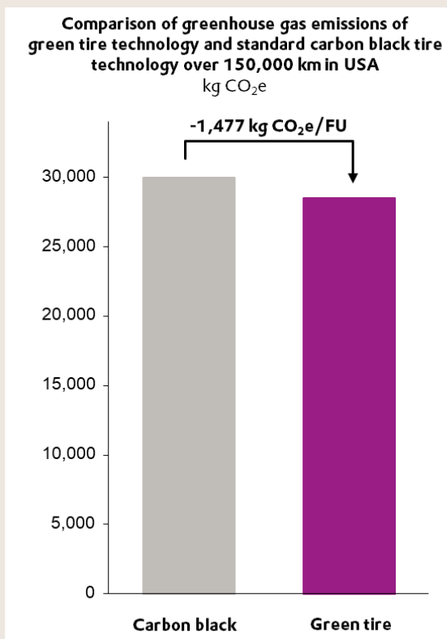
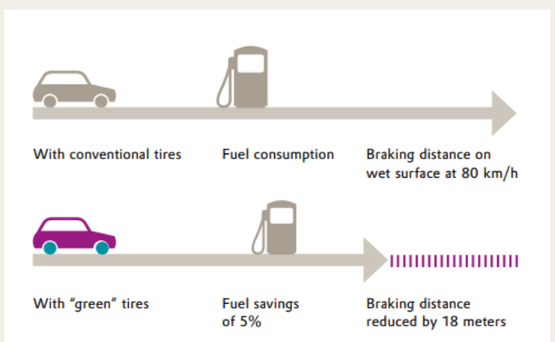
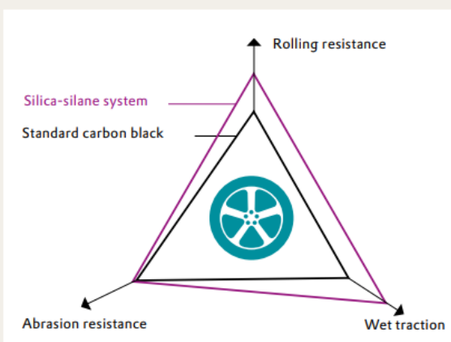


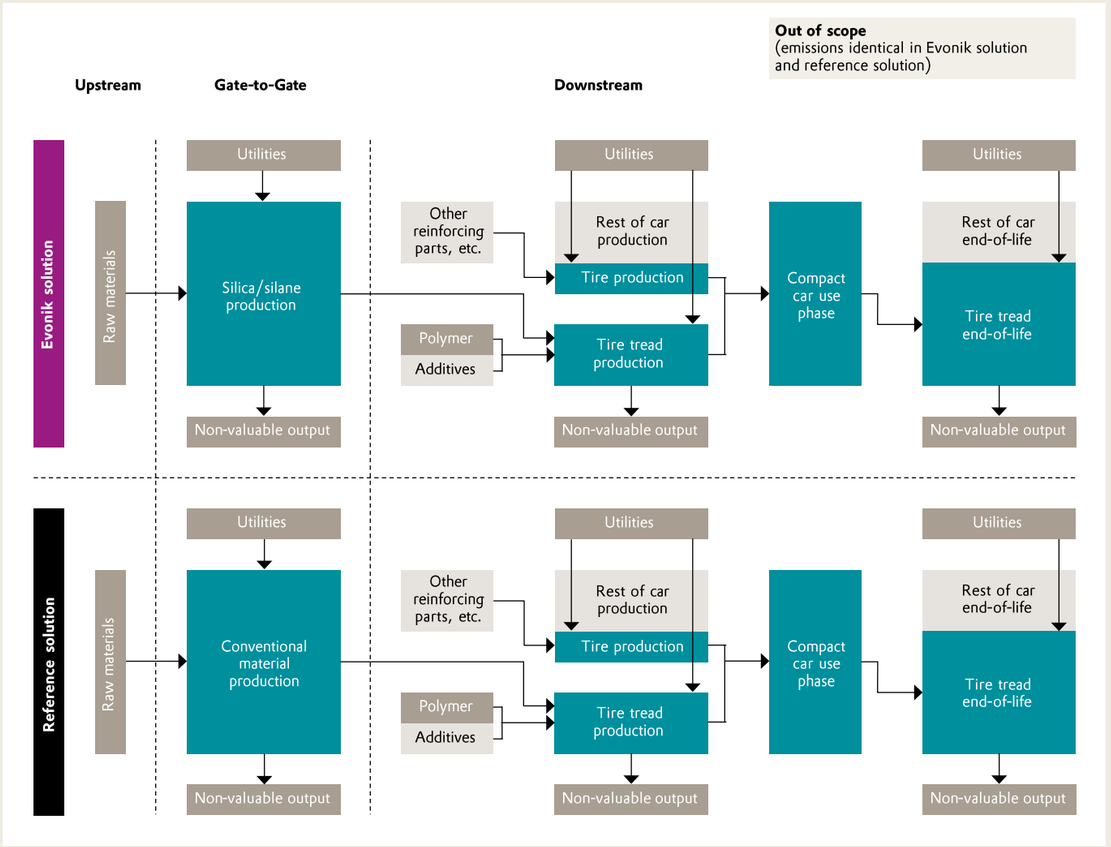

**Figure 1**
The expanded "Magic Triangle" and impact on fuel consumption reveal the Green Tire technology's benefit




| | |
|---|---|
| *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 figure 2. |
| *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. |

Figure 2
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of the Green Tire technology



## POLYVEST® IN GREEN TIRE TREAD COMPOUNDS

POLYVEST® ST-E 60 is a new generation of silane functional rubber additives. It is used in green tire tread compounds to improve the homogenous dispersion of silica particles in the rubber matrix as well as to act as a reactive plasticizer decreasing the viscosity of the compound. It combines the advantages of liquid rubbers and functional silanes. Due to its rubber-based nature it exhibits a natural fit and excellent compatibility with the rubber matrix of tire tread compounds.

As a dual functional material POLYVEST® ST-E 60 forms strong chemical bonds with filler and matrix to create a stable and long-lasting network.

If not using POLYVEST® ST-E 60, the standard plasticizer in tire treads is TDAE oil. This process oil does not chemically react with the system, leading to migration onto the surface and consequently a decrease in tire performance over time.

With POLYVEST® ST-E 60 the migration effect can be overcome, increasing the durability of a tire. In combination with the silica/silane system, POLYVEST® ST-E 60 enables further improvement of key performance indicators of green tire tread compounds such as rolling resistance, abrasion resistance, and wet grip (see figure 3).

This effectively leads not only to improved fuel efficiency, resulting in less greenhouse gas emissions, but also to enhanced driving safety.

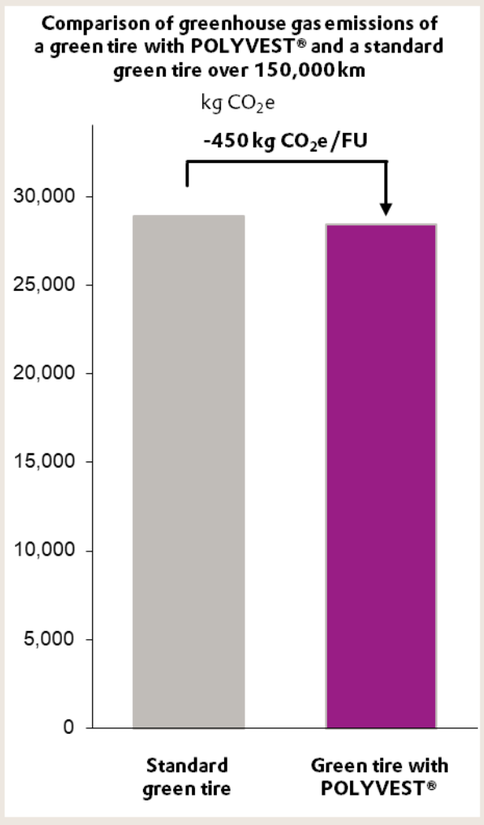
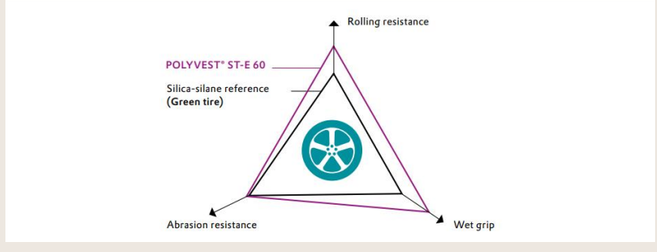
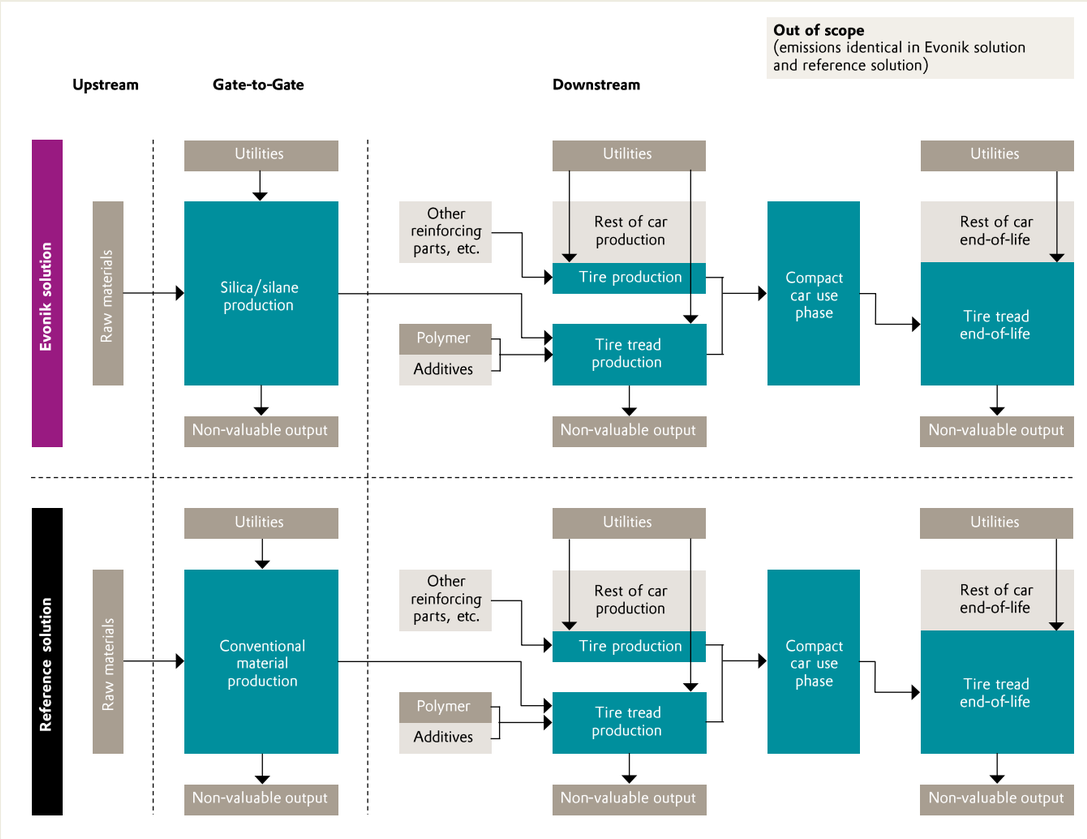



**Figure 3**
The expanded "Magic Triangle" for POLYVEST in green tire tread compounds




| | |
|---|---|
| *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 figure 4. |
| *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®. |

**Figure 4**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of POLYVEST® in green tire tread compounds.



## HYDROGEN PEROXIDE TO PROPYLENE OXIDE (HPPO) PROCESS

Propylene oxide (PO) is an important intermediate in the production of polyurethane — a highly in-demand chemical necessary for the foam used in everyday items like seat cushions, sport shoes, insulating materials, and more. The problem is that conventional production processes for PO tend to generate large quantities of co-products and consume a great deal of resources. Evonik and thyssenkrupp Industrial Solutions (tkIS) have therefore developed an alternative process that is more efficient and more environmentally friendly. Known as HPPO, from "hydrogen peroxide to propylene oxide," this technology involves the direct synthesis of PO from hydrogen peroxide ($H_2O_2$). The process uses far fewer resources than conventional methods, while generating only water as a co-product.

As industries around the world develop increasing sustainability ambitions, face stricter environmental regulations, and are keener than ever on lowering their investment costs, HPPO is becoming a highly attractive technology for PO production.

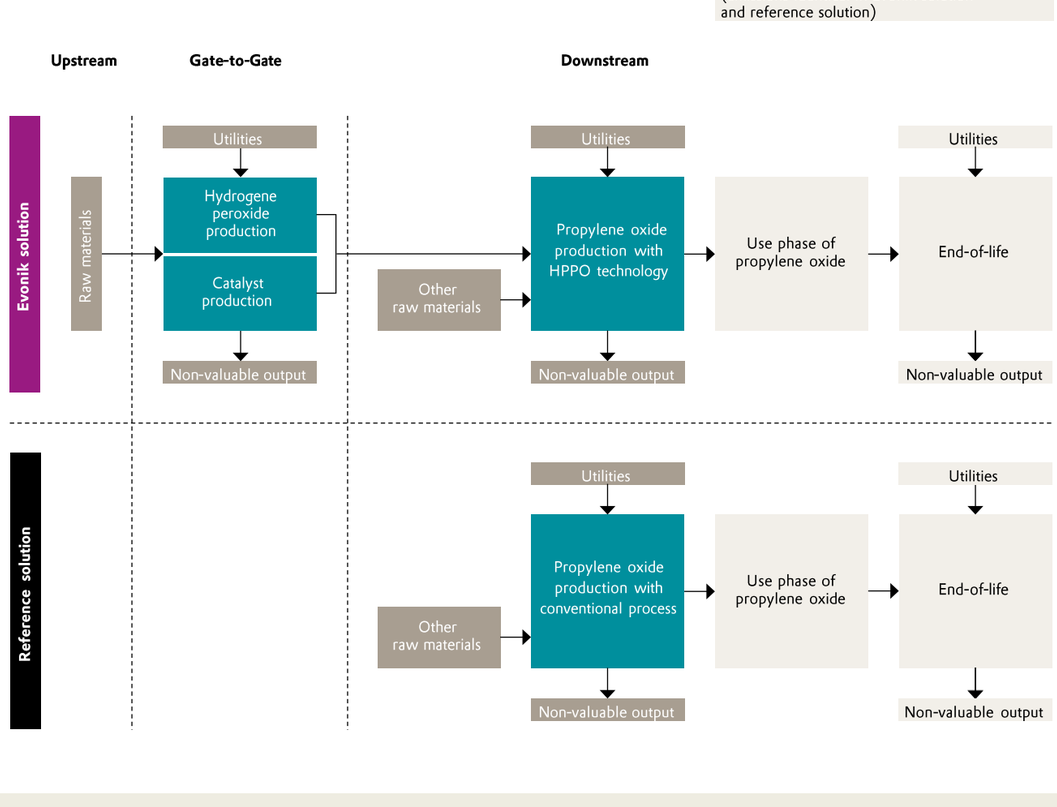
Evonik and tkIS supply PO producers with the license and know-how for the construction and operation of HPPO plants. In addition, Evonik provides the necessary license and know-how for the construction and operation of on-site hydrogen peroxide megaplants, which can be invested by Evonik and/ or the PO producers.

The titanium silicalite-1 (TS-1) catalyst used for the HPPO process was specifically developed by Evonik. In addition, Evonik and tkIS work together with producers on-site on the planning, construction, and commissioning of the plants.

Propylene oxide from the HPPO process shows a by average 27% reduced carbon footprint compared to the average of reference solutions. Depending on the boundary conditions the reduction potential range varies from 17% to 36%.

| | |
|---|---|
| ***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 figure 5. |
| ***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 2024 sales volume of $H_2O_2$ to the HPPO production sites and corresponding production amounts of PO have been considered for calculating total savings. |

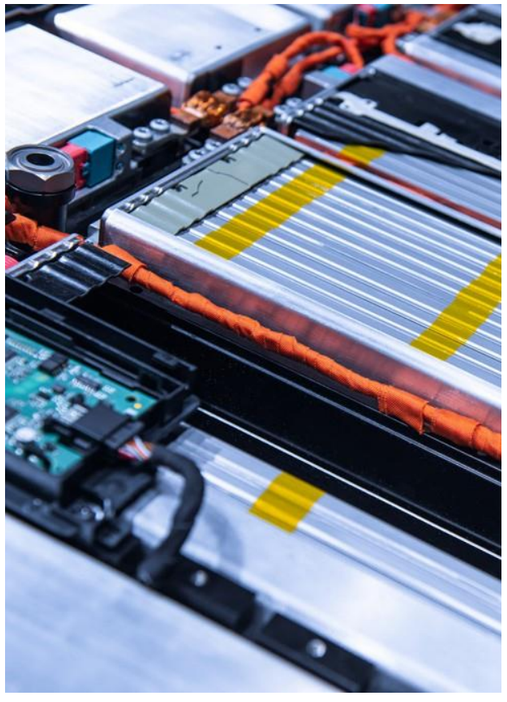
Figure 5
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of the HPPO process



## FUMED METAL OXIDES IN LITHIUM-ION BATTERIES

The global shift to electric mobility is key to reducing greenhouse gas emissions and air pollution from road traffic. Batteries that are powerful yet safe, with quicker charging times and extended driving ranges, are essential for the acceptance of electric vehicles. However, their high energy density puts increased strain on the battery materials and demands better technology development.

High-quality metal oxides from Evonik are used as additives in Li-ion batteries (LIB) to increase their performance, service life ,and safety. AEROXIDE® fumed alumina and fumed titania are produced by flame hydrolysis and consist of nanostructured aggregates with mean aggregate sizes of approx. 100 nm. The white powder provides a very narrow particle size distribution and exhibits high chemical purity. As dry coating on the surface of cathode materials AEROXIDE® acts as a defined cathode electrolyte interface (CEI). It prevents undesired reactions and makes batteries last longer. This increases the service life of a Li-ion battery significantly by about 50%.

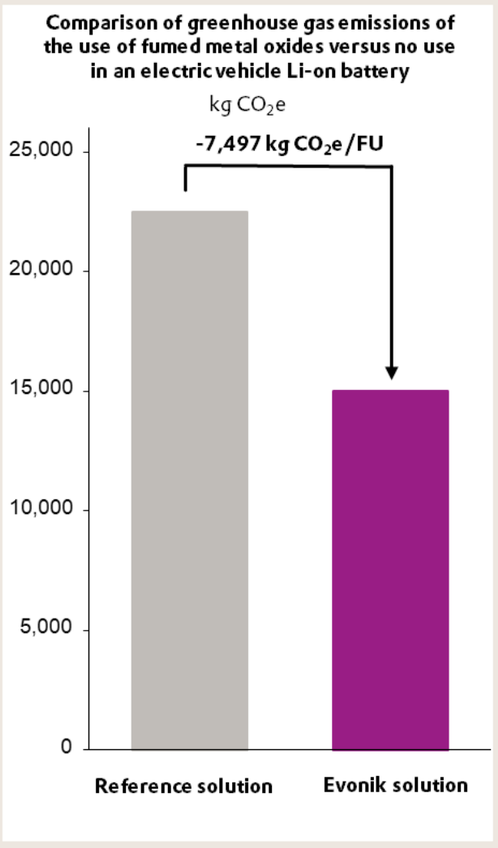


With longer lasting Li-ion batteries, fewer newly produced batteries are required to meet market demand.

The production of Li-ion batteries itself is very energy intensive and causes a lot of greenhouse gas emissions as well as the raw material production and supply.

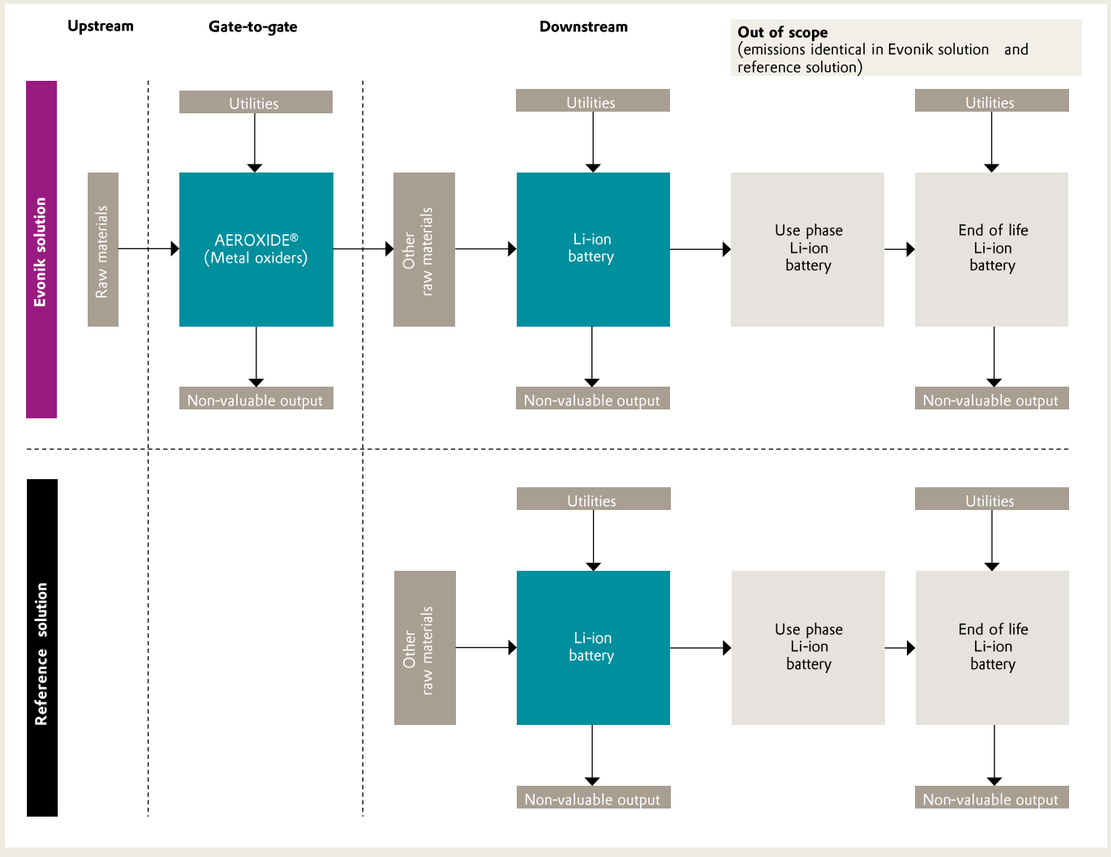
By increasing the battery lifetime and consequently reducing battery production, the Evonik solution avoids the emission of greenhouse gas.

Applications of AEROXIDE® in Li-ion batteries:
- Protective dry coating for cathode materials
- High performance LIB separator coating
- Nanostructured ceramic fillers inside separators
- Additive for electrolyte immobilization (gel polymer type)




| | |
|---|---|
| ***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 the figure 6. |
| ***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. |

**Figure 6**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of AEROXIDE® fumed metal in batteries



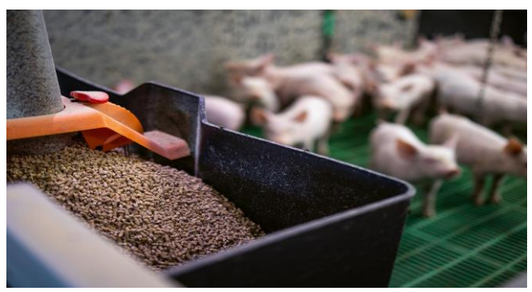
## AMINO ACIDS IN ANIMAL FEED

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.

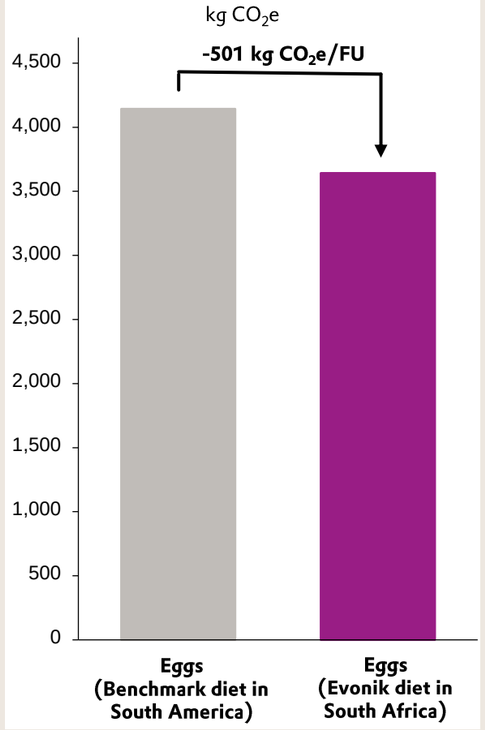


The handprint has been validated by a life cycle assessment and certified by TÜV Rheinland. The functional unit is one ton animal live weight, respective eggs. For example, compared to the industry standard diet, the use of Evonik recommended amino acid supplementation in layer hen feed can reduce the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

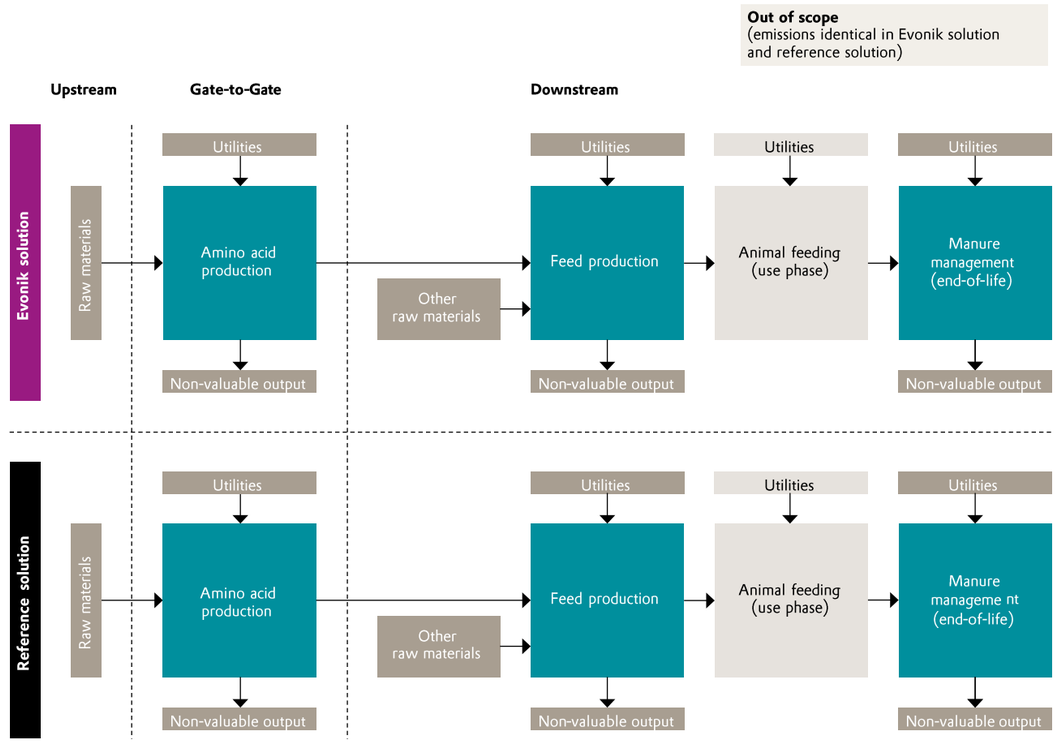
The amino acid addition in the Evonik diet enables a low crude protein diet and the reduction of ingredients with a high carbon footprint.

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




| | |
|---|---|
| *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, for regions South America, North Asia, and South Asia. |
| *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* | 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 the figure 7. |
| *Main parameters and assumptions* | The composition of the feed mixes and the animals' nutritional demands per functional unit related to 2023. 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 2024 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®. |

Figure 7
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of amino acids in animal feed



## IMPROVED HYDRAULIC FLUIDS FOR CONSTRUCTION MACHINERY AND STATIONARY EQUIPMENT

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.

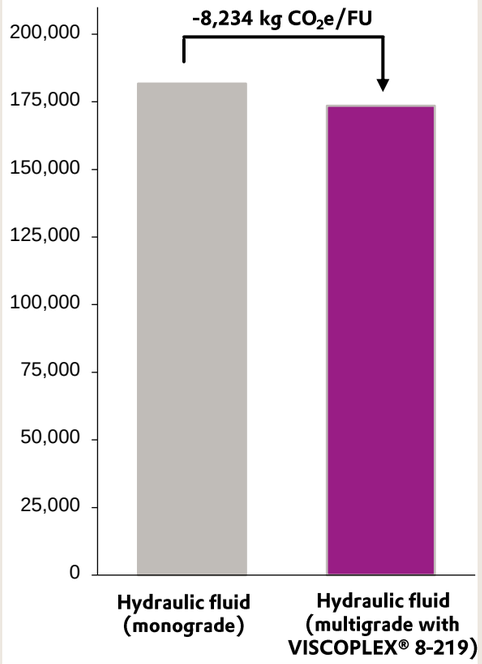
This technology results in more powerful machinery with reduced internal leakage, less hydrodynamic friction and reduced cooling demand. Lower oil peak temperatures potentially enable longer oil drain intervals.

DYNAVIS® is also fit for operating conditions varying from highly dynamic to less dynamic flow patterns of the hydraulic fluid (e.g. in hydraulic manufacturing systems). In all cases, the fluid not only needs to protect the equipment from wear and corrosion, but needs to transmit power efficiently, as well.

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.

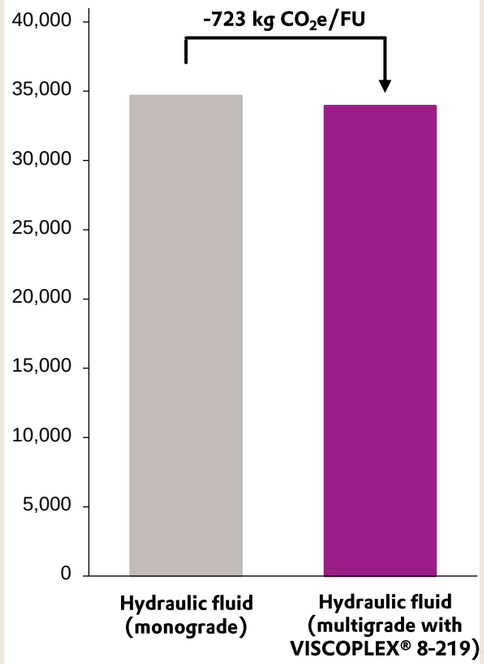
**Comparison of greenhouse gas emissions of DYNAVIS® technology and conventional hydraulic fluids (monograde) in mobile construction machinery**

kg $CO_2$e




**Comparison of greenhouse gas emissions of DYNAVIS® technology and conventional hydraulic fluids (monograde) in hydraulic manufacturing systems**

kg $CO_2$e

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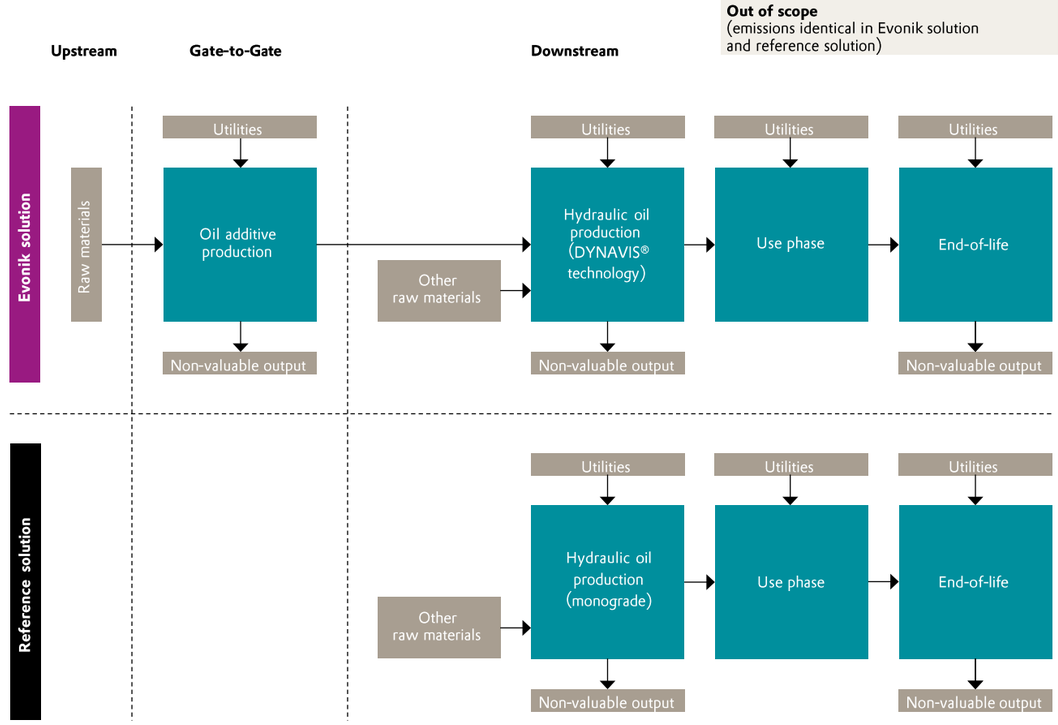
| **Next Generation Solution** | First case: DYNAVIS® technology in hydraulic fluids of hydraulic construction machinery globally. Second case: DYNAVIS® technology in hydraulic fluids of hydraulic manufacturing systems. |
| Reference solution(s) | For both cases: Conventional hydraulic oils without DYNAVIS® 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 | Both cases: Cradle-to-grave. Life cycle steps considered in calculations are shown in Figure 8. |
| 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 2024 has been used to calculate total savings. |

**Figure 8**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of improved hydraulic oils



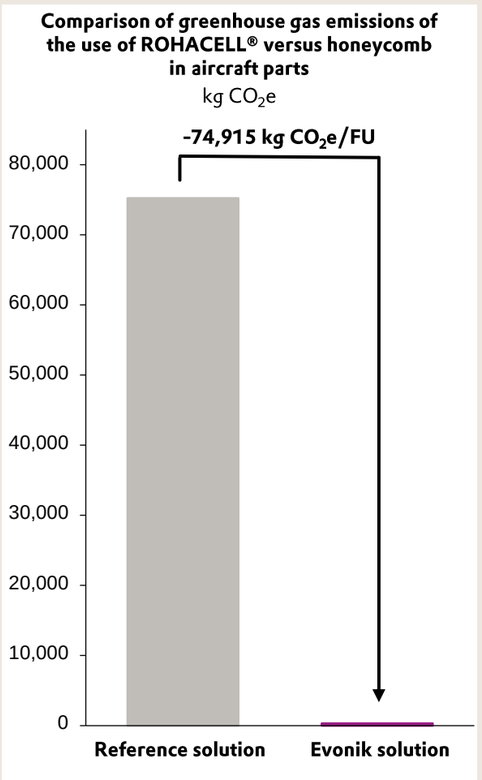
## ROHACELL® FOR LIGHTWEIGHT MATERIALS IN AIRPLANE

The aviation industry faces increasing pressure to reduce its environmental impact, with fuel consumption being major contributor to its carbon footprint. One of the most effective ways to achieve lower emissions is through lightweight construction, as reducing aircraft weight directly translates into lower fuel consumption and, consequently, reduced $CO_2$ emissions.

Evonik's ROHACELL® structural foams provide an efficient lightweight solution for aircraft composite parts, offering significant weight reductions compared to conventional honeycomb materials or monolithic concepts made of metal. By replacing honeycomb structures with ROHACELL®, aircraft manufacturers can achieve a decrease in structural weight, leading to improved fuel efficiency over the aircraft's entire operational lifetime. Given that even small weight reductions can result in considerable fuel savings across thousands of flight hours, the impact of ROHACELL® on avoided emissions is significant.

Beyond weight savings, ROHACELL® also enhances the efficiency of the production process. Unlike honeycomb materials, which require complex processing and additional filling materials, ROHACELL® is easier to integrate into composite structures, reducing material waste and energy consumption during manufacturing. Additionally, its high mechanical strength and durability contribute to longer-lasting components, further supporting sustainability by minimizing the need for replacements and repairs.

Using ROHACELL® in a single aircraft part avoids 74,915 kg $CO_2$e/FU. This is due to the material's lightweight properties, which reduce fuel consumption and greenhouse gas emissions throughout the aircraft's lifecycle.

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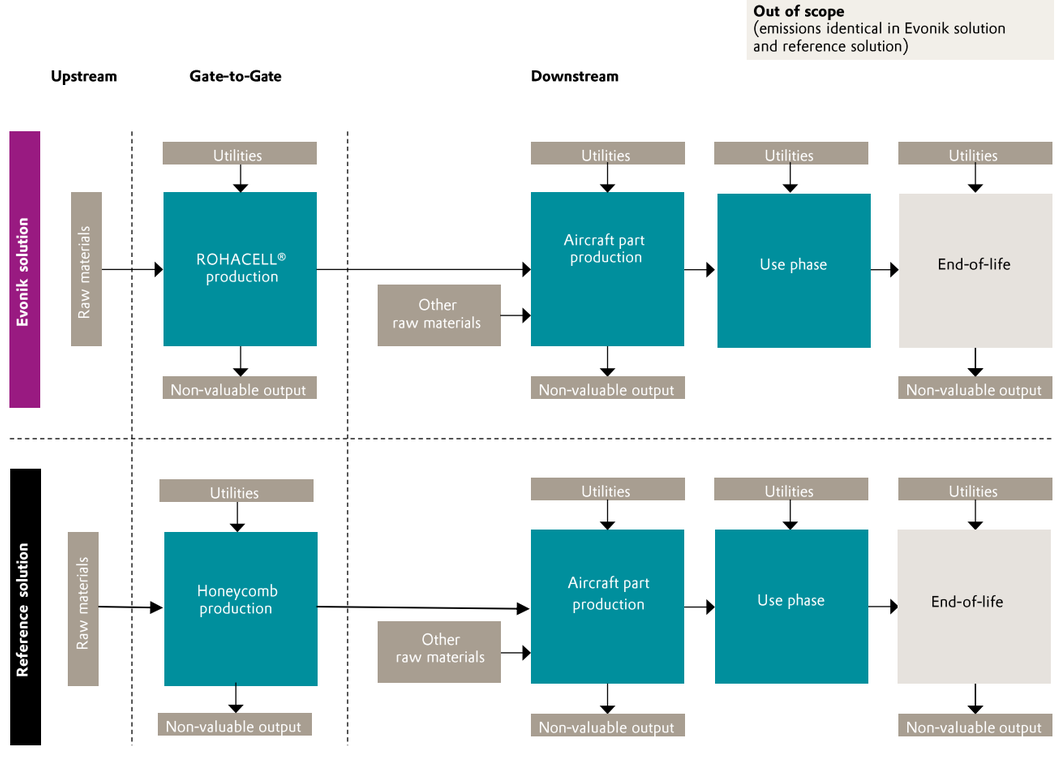
| ***Next Generation Solution*** | ROHACELL® structural foam serves as an effective core material for sandwich composite components in aircraft, facilitating significant weight reduction. By incorporating lightweight solutions in aircraft design, fuel efficiency and minimize emissions through decreased fuel consumption is enhanced. |
| ***Reference solution(s)*** | Honeycomb structures are recognized as the benchmark core material in composite applications. |
| ***Functional unit*** | Total lifetime of a commercial airplane. |
| ***Boundaries*** | Cradle-to-grave. Life cycle steps considered in calculations are shown in the figure 9. Identical emissions for Evonik and reference solution are not considered, e.g., total aircraft production and end-of-life of the aircraft. |
| ***Main parameters and assumptions*** | The literature value for avoided greenhouse gas emissions per kilogram of weight reduction in a passenger airplane has been utilized to assess the environmental impact over the aircraft's total lifetime. Weight reductions are calculated based on comprehensive industry reports that detail the production processes of aircraft parts. |
| ***Background information on the assessment*** | Underlying life cycle assessments of the Evonik products have been conducted in 2024 and are based on production data from 2023. |

**Figure 9**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through use of ROHACELL® in aircraft parts



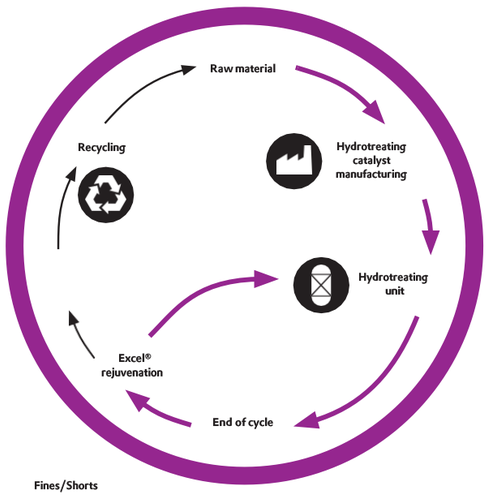
## EXCEL® REJUVENATION OF CATALYSTS

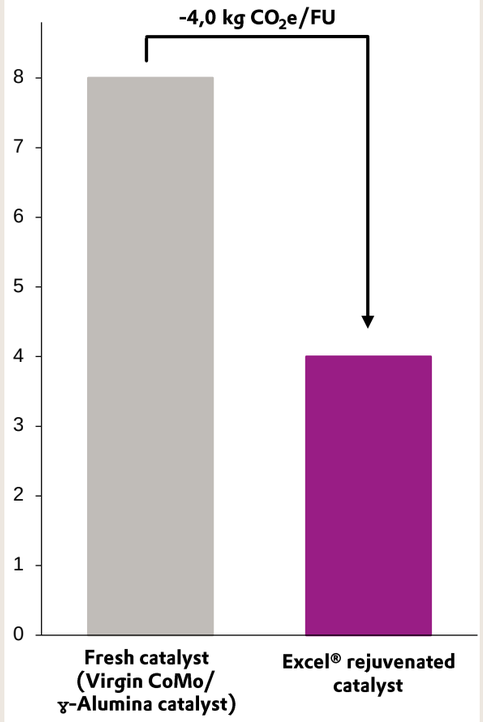
Evonik's Excel® rejuvenation process is a step beyond regeneration. It offers a means for restoring spent catalyst and gives refiners an excellent alternative to fresh catalyst in a wide range of hydrotreating applications from naphtha to heavy gas oil. Prior to the rejuvenation step, the spent catalyst 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 by about 50% thanks to the rejuvenation technology. For every ton of Excel® rejuvenated catalyst sales, approximately 500 kg of virgin resource is saved and 900kg of waste diverted since spent catalyst is recovered and reused.

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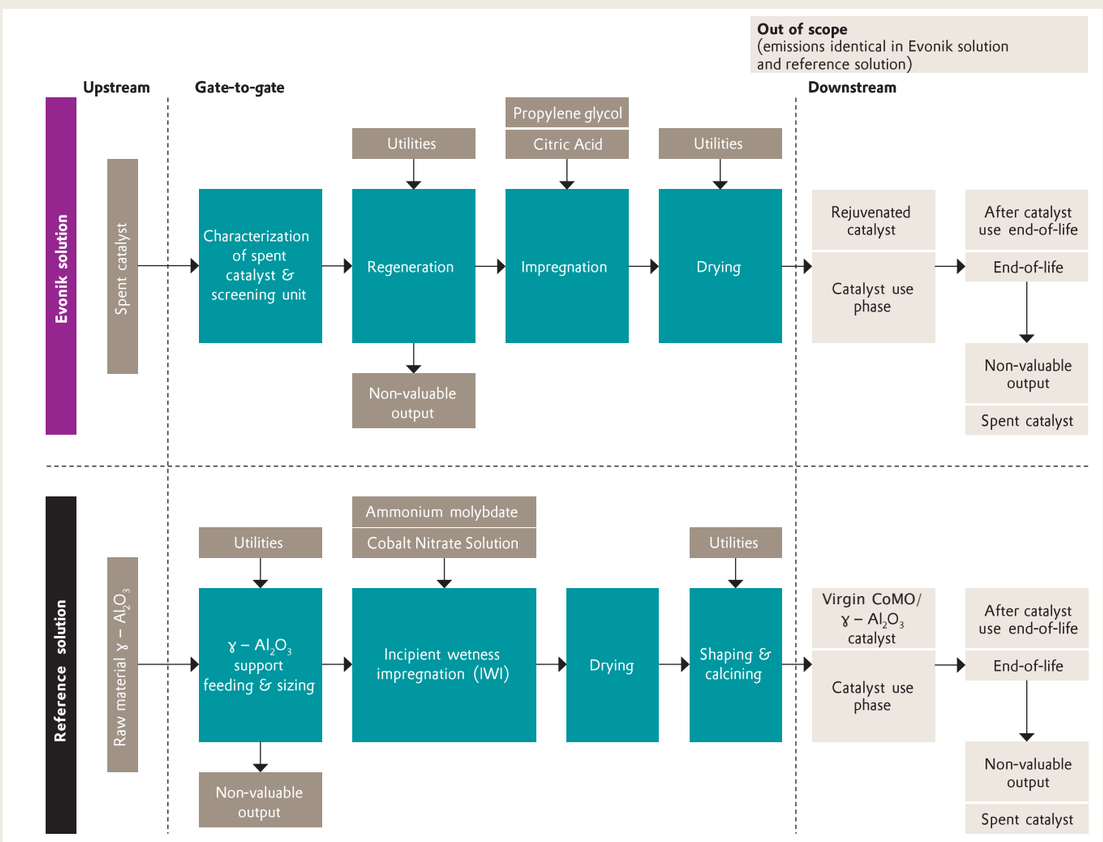
| ***Next Generation Solution*** | Excel® rejuvenated catalyst enables to retain the spent catalyst from the hydrotreating processes |
| ***Reference solution(s)*** | Conventional CoMo/ɣ-Alumina fresh catalyst |
| ***Functional unit*** | Production of 1 kg of Excel® rejuvenated catalyst from spent catalyst |
| ***Boundaries*** | Cradle-to-grave (see figure 10) |
| ***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*** | 2023 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 10
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions in Excel® rejuvenated catalyst



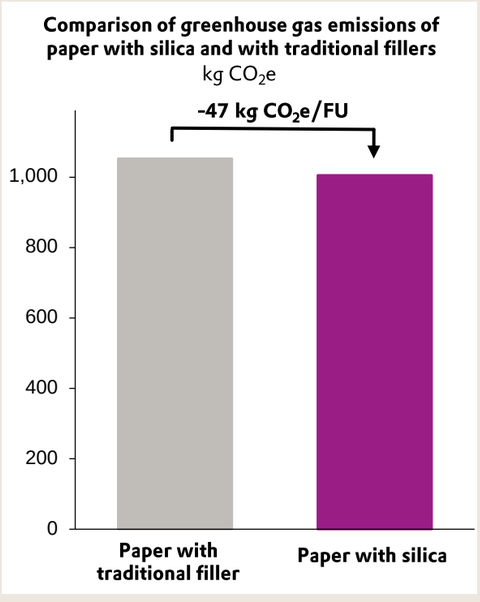
## SILICA FOR PAPER

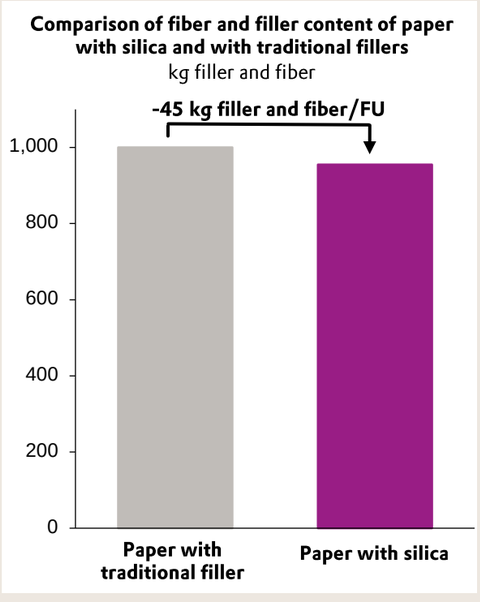
Evonik's Business Line Silica offers a wide product range of precipitated silica and silicate products, fumed silica and fumed silica dispersion materials which are used in paper and board manufacturing applications. HYDREX® P, a silicate-based product, is widely used in different paper and board applications. 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.

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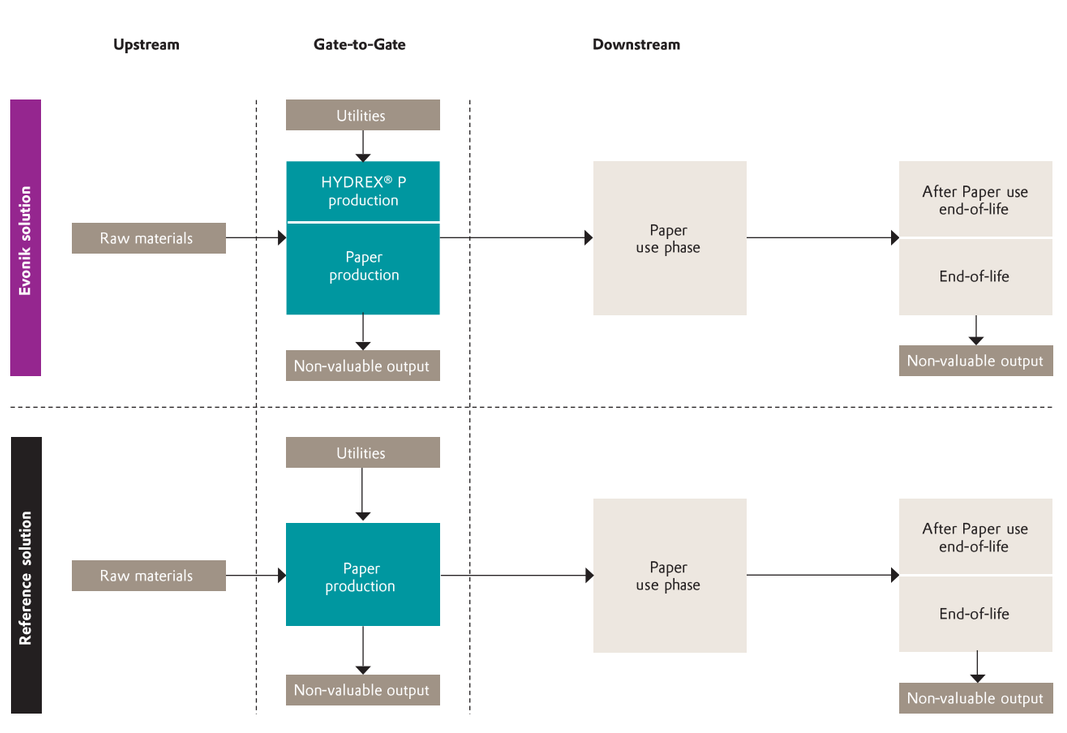
| ***Next Generation Solution*** | HYDREX® P enables multiple ways to improve paper production sustainability by paper lightweighting. |
| ***Reference solution(s)*** | Paper with traditional fillers. |
| ***Functional unit*** | 12,500 $m^2$ printing area. |
| ***Boundaries*** | Cradle-to-gate: Due to 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 11). |
| ***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 11**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of HYDREX® P in paper



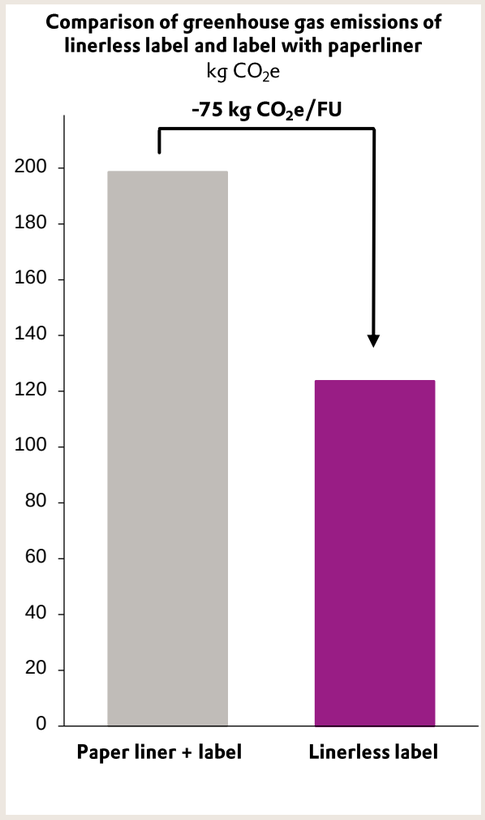
## LINERLESS RELEASE COATING

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 75 kg of $CO_2$e can be saved compared to a standard label, which equates to a saving of 38%.

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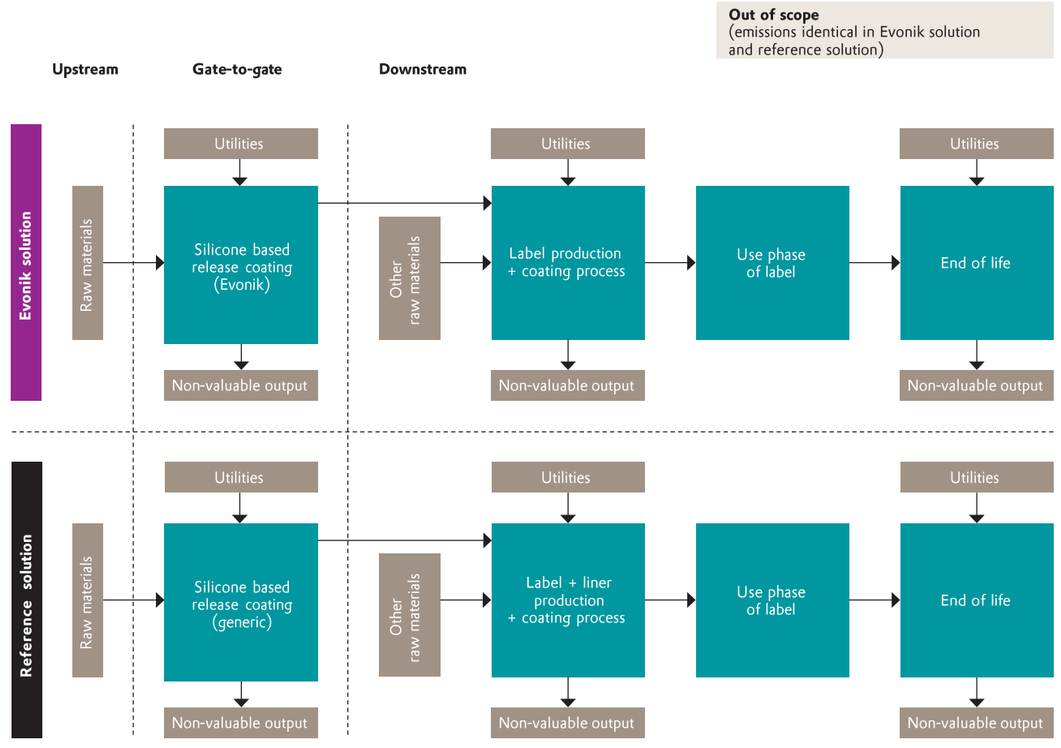
| ***Next Generation Solution*** | Reduction of $CO_2$ through less waste in production, logistic and disposal, as liner material is avoided. |
| ***Reference solution(s)*** | Label with paper liner. |
| ***Functional unit*** | 1,000 $m^3$ label |
| ***Boundaries*** | Cradle-to-grave (Figure 12). |
| ***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 11**
Overview of life cycle steps considered in the comparative analysis of greenhouse gas emission reductions through the use of linerless labels



## PHYTOSQUENE® FOR VACCINE FORMULATIONS

Phytosquene® (plant-based squalene) is one of our Next Generation Solutions due to the positive impact of this product application on marine ecosystems. Most of the squalene currently used globally is obtained from shark liver oil and approximately 3,000 sharks are killed for 1 ton of squalene each year[4]. Evonik is helping to overcome this problem and has launched a plant based squalene, including a GMP grade for the pharmaceutical industry based on amaranth oil.

Shark liver can contain between 50- 80% of crude squalene and the cost as low as USD 7- 15/kg. However, the cost to the loss of biodiversity and damage to the marine ecosystems is incalculable and in many cases, irreversible.

There are three major ways to obtain squalene: from shark livers, plants such as amaranth oil (which contains the highest content of all plants), olive oil, rice bran and others or the squalene can be biosynthesized using e.g. sugar cane as a raw material with yeast in a fermentation process.

The following text is a short summary of the effects on the biodiversity of marine ecosystem if humans continue to obtain squalene from sharks and why sharks are absolutely crucial for the health of the oceanic ecosystem.

There are over 500 different species of sharks and sharks are the top predators in the oceans. They are very diverse in their sizes, shapes and especially in their diets. Sharks do not eat only one single type of species, so when populations of certain species are low, the sharks change to other more available food sources. This enables the low populated species to grow again.

Also, sharks tend to eat prey that is more accessible e.g. the old or sick animals – this means that sharks play an important role in stopping diseases from spreading and contributing to the health of the ocean by enabling healthier gene pools.

If sharks were eliminated completely, the next level predators may become the dominate species and may only feed on a single type of fish – and this could eliminate all the fishes it feeds on, and consequently it may, itself, not have anything to eat in the future.

**Please note**

that the following handprint examples have not been quantified as avoided emissions

Sea meadows play a very important role in capturing carbon that is present in the ocean – similar to plants on land absorbing carbon dioxide gas from the air. The presence of sharks in these areas, ensures that creatures such as turtles do not over graze in one specific area. Sea meadows also help to build and maintain coral reefs.

An estimated 4,000 species of fish are dependent on the algae found among the coral reefs (these reefs are home to about 25% of all marine life in the ocean).

Finally, nobody knows how many sharks are actually in our oceans, but we do know that deepwater sharks have some of the longest known life spans and very low reproductive rates (most shark species can take up to 10 years to reach sexual maturity some longer and some have to be 30-40 years old before they can reproduce), but they also only reproduce every 1-2 years with a handful of pups. This means that they have very low population growth rates.

On top of the marine biodiversity aspects, animal-based squalene has the potential for pathogenic transfer to humans, shark livers are contaminated with heavy metals such as mercury (from the pollution in the oceans) and consistency in quality can also vary dramatically. This makes plant based squalene a very attractive option.

Evonik's plant based squalene is extracted from Amaranth oil, which not only has the highest squalene content of all the plants, but is available globally as it can be grown in ambient temperatures – ensuring security of supply.

The Amaranth plant reaches full maturity in about 90 days before it can be harvested. The oil is fairly easy to extract from the seeds and then purified.

Squalene derived from plant based sources does not have the same impurities as those found in squalene from sharks and it is more consistent in quality. This is extremely important to know, especially when we are talking about pharmaceutical applications. Moreover, due to the higher purity after processing of the amaranth oil, there is no chance of pathogenic transmission thus contributing to patient compliance in the societal dimension.

[4] https://www.robstewartsharkwaterfoundation.org/articles/shark-squalene-in-cosmetics#:~:text=It%20takes%203000%20sharks%20to,sold%20to%20the%20cosmetics%20industry

# SUSTAINABLE CONTAMINATED GROUNDWATER REMEDIATION AT A BROWNFIELD IN GERMANY

**Please note**

. . . . . .

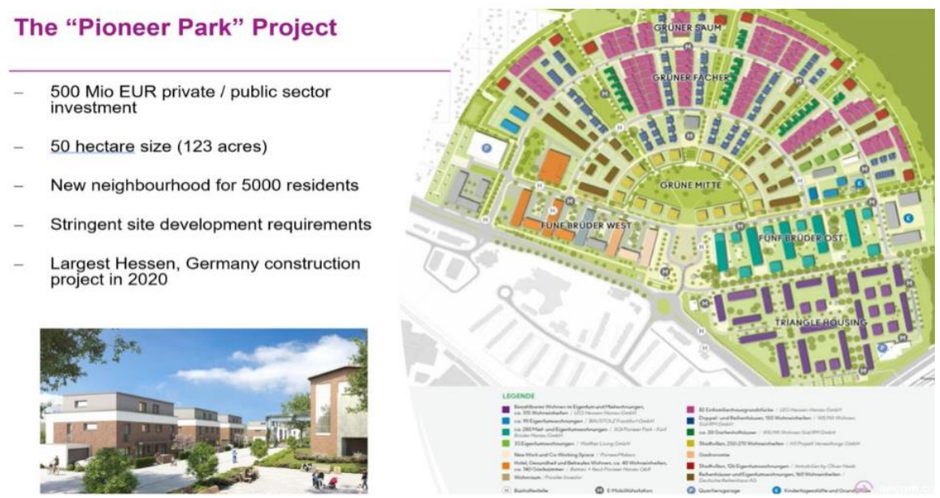
that the following handprint examples have not been quantified as avoided emissions

The term Brownfield describes land which is abandoned or underused, usually in part because of concerns about contamination. Redeveloping these properties is often an attractive target for investor groups like real estate developers and municipalities. That`s because these sites are very often in highly desirable locations and are potentially worth a lot of money, either in tax revenue, property speculation, etc. Common clean-up methods are used, such as excavating the contaminated land and trucking it to an offsite location, or treating the groundwater by pumping it out to an aboveground filtering system that removes the contaminants. These approaches are selected because they don't require much time to be designed and implemented. But the downside is that such "remediation" activities may cause a greater net negative impact than the contamination impacts themselves which they are trying to address. What are termed "green and sustainable" remediation technologies, can reduce the environmental footprint of remediation activities and maximize the overall net benefits of a project.

This case study location is the Pioneer Park redevelopment, a large property in Hanau, Germany previously used as a military installation. The re-zoning permits that the real estate developers needed to allow residences to be built there required remediation of chlorinated hydrocarbon (CHC) contaminated groundwater plumes at the site. After many months of evaluation and review by the consultants, our EHC® technology was selected for this challenged.

## Approach/Activities

EHC® is a product that generates multiple contaminant degradation pathways, often referenced as In Situ Chemical Reduction or "ISCR". The main mechanisms revolve around biological and abiotic reductive processes in situ conducive to the "reductive dechlorination process" of organic contaminants. EHC® is primarily comprised of a variable mixture of micro-scale Zero Valent Iron (ZVI) and a solid organic carbon source. One of the most compelling features of EHC® is that it is made from bio-based and recycled materials, which helps us position it as a sustainable solution in the market. The ZVI portion is typically sourced as a raw material from scrap-iron and steel production waste, after which it`s milled and lab tested for suitability before usage. The plant carbon component is sourced as a food production by-product, often collected as waste material from the wheat milling industry. So basically, we are recycling what would be discarded waste materials into a very effective remediation technology that is used to destroy soil and groundwater contamination. For over 20 years now, EHC® has been demonstrated to be safe and effective at several thousand sites worldwide.




## Results/Lessons Learned

Several take-aways were discerned from the remediation activities. These include the conclusion that a single amendment injection may allow for achieving stringent remediation goals (i.e. total CHCs from 12 mg/L to the German drinking water standard of 20 µg/L).

A comparative life cycle assessment was conducted to compare the secondary impacts of Evonik EHC® in-situ application versus a conventional ex-situ remediation technology, which involves pumping groundwater to an aboveground filtering system that removes contaminants. The functional unit is the in-situ remediation of 210,000 tons of soil contaminated with approximately 3.3 tons of CHC to a level below the remedial goal of 20 µg CHC/L groundwater, representing the rigorous German drinking water standard. The system boundary is cradle-to-grave. In comparison to the above-mentioned ex-situ remediation technology, the use of EHC® for in-situ application demonstrated potential savings of up to 60% in greenhouse gas emissions. Additionally, the in-situ application of EHC® reduces the need for prolonged electricity consumption. As a result, the secondary ecotoxicity impacts on freshwater systems linked to the German average electricity mix tend to be lower.

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