LCA carbon footprint summary report for Eastman Saflex Clear (R series) PVB interlayer

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Executive summary and key takeaways

Eastman's advanced interlayers group is proud to present this cradle-to-gate life cycle assessment (LCA) for Eastman Saflex Clear (R series) PVB interlayer. This baseline environmental performance enables us to identify opportunities for further improvement on embodied carbon and other impact indicators. Furthermore, this LCA serves as a reference for developing a road map toward our zero-carbon aspirations in 2050. This brochure is condensed from the full and confidential LCA study, which has been third-party reviewed and certified by Quantis.

The key conclusions are:

- The baseline carbon footprint of Saflex R series interlayer is 4.5 kg CO_2-eq./kg or 3.6 kg CO_2-eq./m^2.
- The environmental profile of Saflex is largely dependent on raw materials.

Background

Creating a sustainable story starts with data that is credible, transparent, and scientifically supported.

Eastman is a global specialty materials company dedicated to building a circular economy to reduce the environmental impact of its processes. This commitment is shared across all our business segments, including advanced interlayers, which manufactures and markets Saflex. In a landscape with ever-changing rules and regulations regarding circularity, it is important to create a solid understanding of where we are as a business and how we see the way forward. Therefore, we've used LCA methodology to create a robust baseline of our environmental performance, providing an understanding of major opportunities for improvement.

Introduction

Eastman, a world leader in polyvinyl butyral (PVB) interlayers, continues to innovate its portfolio to meet the needs of the laminating industry with products offering superior processing, laminate performance, and durability. It is our goal to build the bridge between our high-quality standards and sustainability. Therefore, we conducted a baseline LCA on Eastman advanced interlayers division's largest volume product, Saflex Clear RB41 (R series) PVB interlayer. The following describes the global production process for Saflex Clear RB41 and the resulting environmental footprint using Eastman LCA methodology. RB41 serves as the proxy value for the Saflex Clear (R series) portfolio.

Scope

Study goals

This study evaluates the global warming potential and other environmental indicators of Saflex Clear RB41 production. As such, it helps us better understand its life cycle impacts and ultimately helps our customers and stakeholders—architects, designers, building and construction professionals, glass manufacturers, and glass laminators—create compelling sustainability stories for their varied audiences. The study meets ISO14040/ISO14044 guidelines and has successfully undergone a third-party review by Quantis.

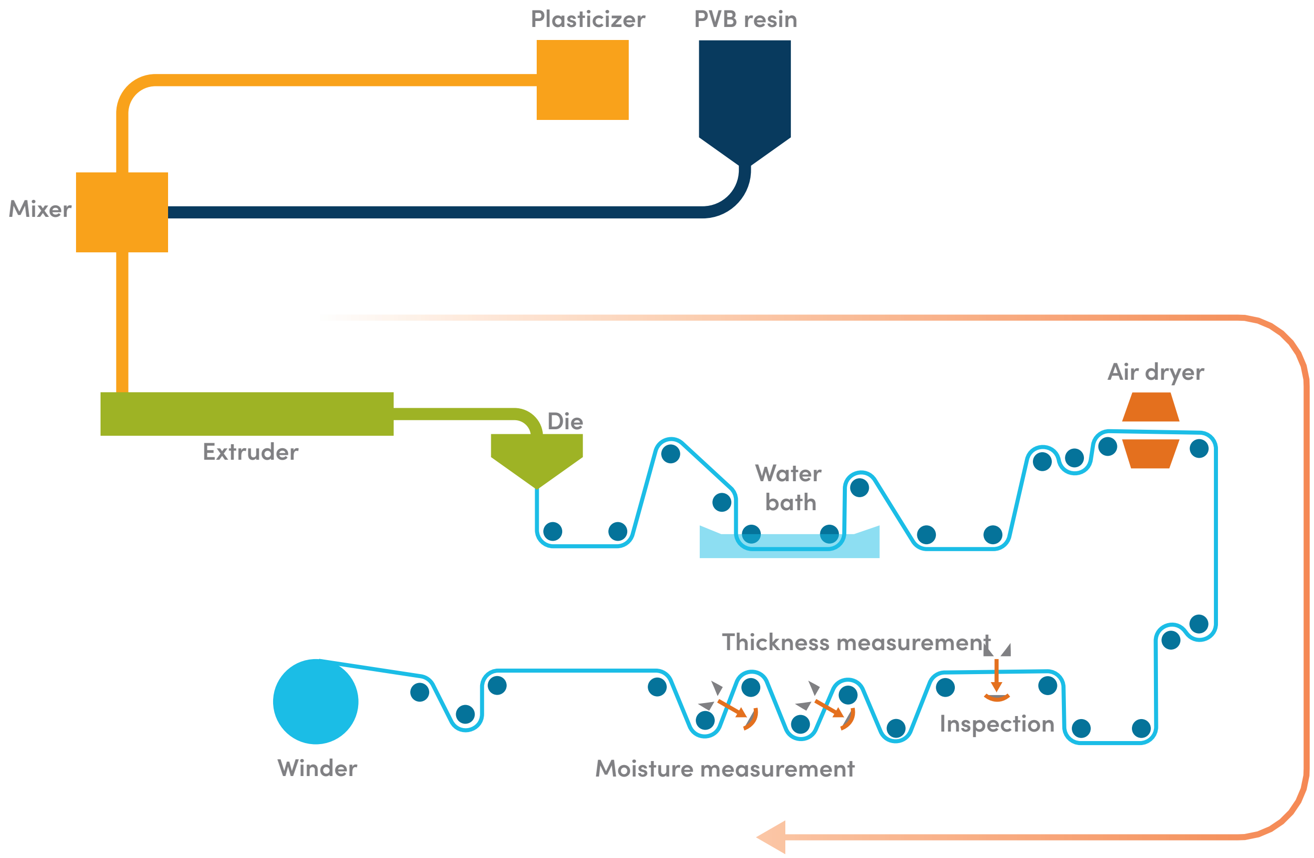
Functional unit

The functional unit for this study is 1 kg of Saflex Clear RB41 (0.76 mm) at plant, manufactured in 2019. In general, 1 m^2 of RB41 weighs approximately 0.8 kg. RB41 is the largest volume product and therefore, serves as the proxy value for the whole Saflex Clear (R series) portfolio (including the adhesion ranges RC41/RA41, variable thicknesses and dimensions).

System boundary

Note that baseline LCA results are based on the production of Saflex PVB made exclusively with virgin raw materials. The studied system comprises manufacturing an interlayer product for laminated glass. Saflex is a PVB interlayer supplied as a thick film designed to adhere two layers of glass, creating a laminated glass system. It is used in automotive and architectural spaces and, depending on its design, may provide safety against impact and glass spalling, security against intrusion and forced entry, and enhanced sound damping and solar absorption.

PVB interlayer production process



The scope of this study is cradle to gate, including resource extraction, shipment of raw materials, and production. Infrastructure (buildings, trucks, roads, shipping containers, and storage) and corporate overhead (physical equipment, employee travel, office buildings, etc.) are excluded. The study does not include implications of recycling or the inclusion of recycled content.

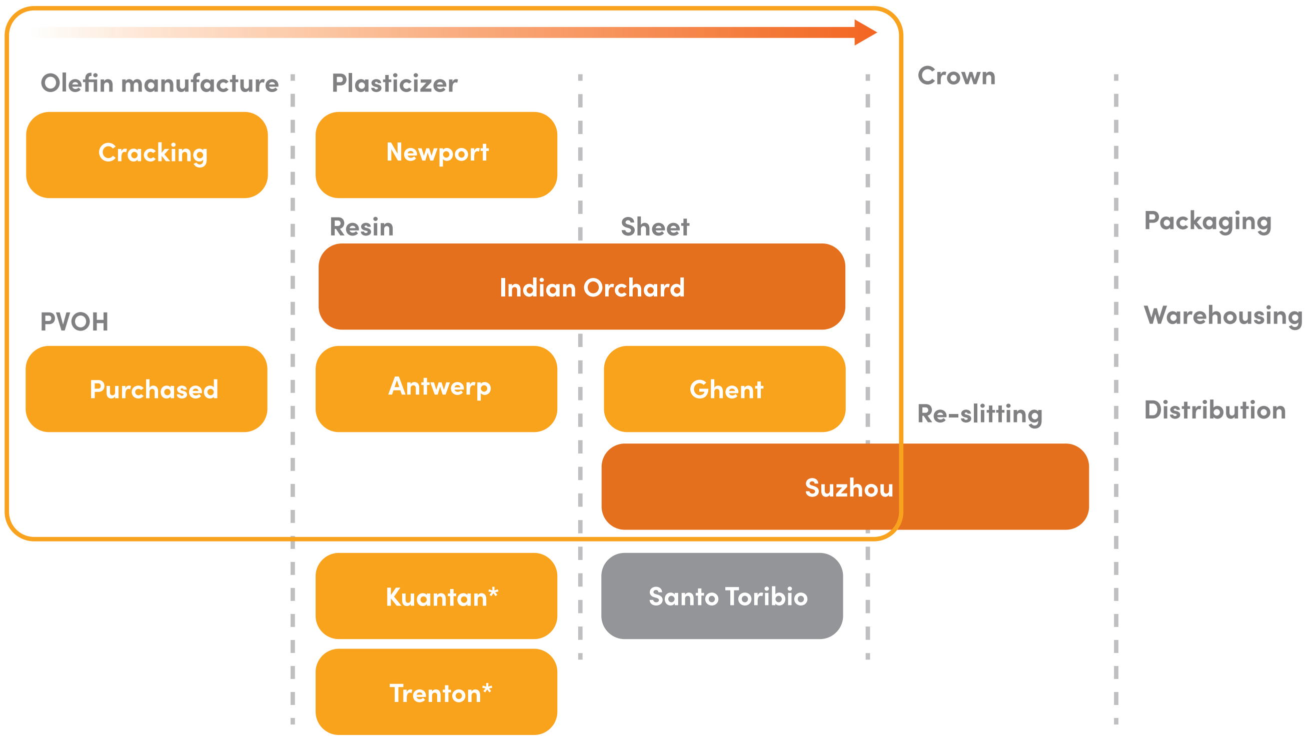
The supply chain is modeled within Eastman or contracted suppliers and located at various production locations worldwide including Indian Orchard, Massachusetts, U.S.A.; Ghent, Belgium; Suzhou, China; and Santo Toribio, Mexico. Raw materials are purchased from external suppliers and modeled with generic data. The system includes the acquisition of raw materials, inputs and outputs for each site (and each manufacturing line), transportation of resin to the PVB plant, and all other utility charges associated with each manufacturing line.

Final packaging and distribution can vary depending on the application and are excluded from this study. Packaging, warehousing, and distribution of PVB may not necessarily be included in comparable LCAs for laminated glass systems because the processed glass product category rules (PCR) refer only to the packaging of final laminated glass. Similarly, the use phase and end of life are excluded because of the different possible applications of these products. The temporal scope covers all Saflex Clear RB41 production that occurred in 2019. This temporal scope provides recent data and the best description of practices. The study assumes that the Santo Toribio site behaves similarly to the major production areas and that the study can serve as a proxy for average interlayer production. The study further assumes that transportation of relevant intermediates follows relatively efficient shipping routes.

Saflex Clear RB41 production involves extruding PVB resin and a plasticizer. The PVB resin is made by reacting *n*-butyraldehyde with polyvinyl alcohol.

A step-by-step outline of major material flows is presented in the following figure.

LCA scope



*Transportation from these locations to sheet manufacturing is included.

Life cycle inventory

Data and calculations

We used GaBi v.10.6.0.110 software to develop the life cycle inventory (LCI) and impact assessment modeling. A combination of external data sets in the software (GaBi internal database and EcoInvent 3.8) and internally collected primary data from manufacturing were used to create the GaBi models for Saflex Clear RB41.

We based the inventory flows for Saflex Clear RB41 on information collected through Eastman's cost-reporting system for 2019, supported by specific data provisions from manufacturing experts in each area. We also used LCI data from earlier models, including plasticizer and *n*-butyraldehyde. Saflex Clear RB41 represents about 20% of the 2019 global produced interlayer volume. Background data sets and corresponding data quality are assessed with a pedigree matrix. Transportation, energy, and water consumption are based on internal data and are modeled with respect to the completeness and reliability, and temporal, geographic, and technological correlation.

The following processes are excluded from the scope due to expected contributions below the cutoff criteria: infrastructure, packaging, labor working, commuting, and administrative systems.

Allocation principles

1. Coproducts

Coproducts that occur in the system boundaries are handled according to the Life Cycle Metrics for Chemical Products[1] guidance decision tree (section 4.7.1.2), and any credit is given as appropriate.

2. Comparability

The study is not intended for comparing assertions. Before any communication is done on benefits of this product compared to other solutions, further investigation should be conducted to ensure comparability of the scopes of the studies, specifically related to the boundaries and life cycle phases included.

3. Cutoff rules

Quantitative cutoff criteria are guided by the following rules. Process inputs may be excluded for either:

- Any inputs less than 0.5% of total input mass or energy
- Any inputs deemed to have less than 1% contribution to relevant impact indicators (per engineering judgment)

[1] *Life Cycle Metrics for Chemical Products (wbcsd.org)*

Life cycle impact assessment

The impact assessment phase of an LCA is aimed at evaluating the magnitude and significance of potential environmental impacts across various categories. The impact assessment methodology implemented in the GaBi software was the Environmental Footprint (EF) 3.0 method developed by the European Commission. It is a state-of-the-art method relevant to many Eastman stakeholders. The EF method assesses 16 different potential impact categories, of which 14 were assessed in this study. Land use and ionizing radiation impacts were excluded due to low relevance and lack of data. The methodology and its impact categories are described in Appendix 1.

The European Commission's Joint Research Centre classifies each impact category according to the maturity and robustness of its underlying models:[1]

- Level I: Recommended and satisfactory
- Level II: In need of some improvements
- Level III: To be applied with caution

These levels should be considered when interpreting the results.

The impact assessment results are shown in Table 1. The carbon footprint presented according to the EF3.0 Climate Change Impact Indicator is based on the weighted average of the three studied production sites. The Ghent site is the largest producer for Saflex Clear RB41, followed by the Suzhou and Indian Orchard sites. The value can be used as a proxy for the smaller production site, Santo Toribio.

[1]*European Commission (2017). PEFCR Guidance document, Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3.*

Cradle-to-gate life cycle impact assessment results per kg Saflex Clear (R series), product environmental footprint

Impact indicator	Global weighted avg. per kg
EF 3.0 Acidification [mole of H+ eq.]	0.0115
EF 3.0 Climate change, fossil [kg CO_2 eq.]	4.5
EF 3.0 Ecotoxicity, freshwater—total [CTUe]	37.2
EF 3.0 Eutrophication, freshwater [kg P eq.]	-7.22E-05
EF 3.0 Eutrophication, marine [kg N eq.]	0.00247
EF 3.0 Eutrophication, terrestrial [mole of N eq.]	0.0268
EF 3.0 Human toxicity, cancer—total [CTUh]	8.17E-10
EF 3.0 Human toxicity, noncancer—total [CTUh]	3.11E-08
EF 3.0 Ozone depletion [kg CFC-11 eq.]	2.64E-09
EF 3.0 Particulate matter [disease incidences]	9.68E-08
EF 3.0 Photochemical ozone formation, human health [kg NMVOC eq.]	0.00971
EF 3.0 Resource use, fossils [MJ]	109
EF 3.0 Resource use, mineral, and metals [kg Sb eq.]	-1.92E-06
EF 3.0 Water use [m^3 world equiv.]	2.08

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Conclusion and interpretation

The baseline carbon footprint of Saflex Clear (R series) PVB interlayer is 4.5 kg CO_2-eq./kg. The study is based on the RB41 product, serving as a proxy for the whole Saflex Clear (R series) portfolio. This baseline is the starting point for all 30-gauge (0.76-mm) monolayer products made exclusively with virgin raw materials. It is also the global weighted average for the investigated production sites in Ghent, Indian Orchard, and Suzhou and can be used as a proxy for Santo Toribio.

This study shows that the environmental profile of Saflex interlayers is largely dependent on raw materials (> 80%). A variety of different manufacturing locations are investigated, but to improve the accuracy of this study, Eastman could also include small sites such as Santo Toribio and incorporate those sites into the global average.

Not all the data sets are equal in quality, temporal, or geographical representativeness, and care should be taken to understand where the background data needs improvement. More up-to-date Eastman and purchased data sets are almost always preferred. A specific project is running for the resin and plasticizer model to make improvements in their data quality.

Saflex PVB interlayers represent just one part of the laminated glass system; and while their cradle-to-gate impacts are important, the performance of the laminated glass in its final application represents a potentially far greater tool for reducing greenhouse gas (GHG) emissions during building or vehicle use (referred to as operational carbon). Thus, Saflex's GHG profile is not included in this study.

Critical review

A critical third-party review of the full confidential report was performed by an independent consultant, Quantis, and a final review statement was issued on April 9, 2022. The reviewer confirmed the study followed the guidelines and is consistent with the international standards for LCA (ISO 14040:2006 and 14044:2006).

Appendix 1: Overview of life cycle impact assessment using EF methodology

LCA is a systematic approach to assess the environmental aspects and potential impacts of product systems.
ISO 14040:2006 defines four key stages of an LCA:

1. Goal and scope definition
2. Life cycle inventory (LCI) analysis
3. Life cycle impact assessment (LCIA)
4. Interpretation

LCI involves a compilation of the flows of energy, emissions, and materials between the product system and the environment throughout the life cycle scope. The LCIA accounts for how LCI flows contribute to various environmental impact categories according to standard impact assessment methodologies. The LCIA is intended to provide a multi-criteria perspective of environmental and resource issues.

LCI assessment results present potential and not actual environmental impacts. They are relative expressions that are not intended to predict the final impact or risk on the natural media or whether standards or safety margins are exceeded. Additionally, these categories do not cover all environmental impacts associated with human activities.

[1]*It is the result of a European Commission program that analyzed several LCIA methodologies to reach consensus on the best state-of-the-art impact assessment science. Sala, et al. Suggestions for the update of the Environmental Footprint Life Cycle Impact Assessment. "Impacts due to resource use, water use, land use, and particulate matter," EUR 28636 EN, Publications Office of the European Union, Luxembourg, 2019, JRC106939.*

EF methodology

Different LCIA methods are available. The method used in the Saflex Clear (R series) PVB interlayer study is the EF method[1] version 3.0 (European Commission 2017). It is the official method to be used in the Product Environmental Footprint (PEF) context of the Single Market for Green Products (SMGP) initiative (European Commission 2013) and is relevant to many of Eastman's stakeholders. The EF method specifies standard methodologies for modeling potential impacts across a defined set of environmental impact assessment categories.

The results of the EF LCIA are midpoint scores for each impact category. The score in each impact category is set to a common basis. For example, the climate change impact potential is calculated by using global warming potential (GWP) characterization factors for all greenhouse gas emissions and expressing the results on the basis of kilograms of carbon dioxide equivalents emitted to the atmosphere. The EF method assesses 16 impact categories; however, only 14 of them were evaluated in this study. Land-use change and ionizing radiation were excluded due to low relevance and lack of data.

Climate change

This is an indicator of potential global warming impacts due to emissions of GHG to the atmosphere. GWP accounts for radiative forcing caused by GHG emissions such as carbon dioxide (CO_2), methane (CH_4), or nitrous oxide (N_2O). The capacity of a GHG to influence radiative forcing is expressed in kilograms of carbon dioxide equivalents and considers a time horizon of 100 years, following the guidelines from the Intergovernmental Panel on Climate Change (IPCC 2013).

Model: Bern—GWP over a 100-year time horizon (IPCC 2013)

Unit: kg CO_2-eq

Acidification

This indicator denotes the potential acidification of soils and water (i.e., acid rain) due to emissions of gases such as sulfur oxides and nitrogen oxides. Acidifying substances cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems, and the built environment. The impact metric is expressed in mole H^+-eq (hydrogen ions to soil and water equivalents).

Model: Accumulated exceedance model (Seppälä et al., 2006; Posch et al., 2008)

Unit: mol H^+-eq

Freshwater eutrophication

This indicator denotes potential degradation of freshwater aquatic ecosystems due to excessive enrichment of nutrients such as phosphorus materials. The impact metric is expressed in kilograms of phosphorous equivalents.

Model: EUTREND (Struijs et al., 2009)

Unit: kg P-eq

Marine eutrophication

This category addresses the impacts from nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilized farmland that accelerate the growth of algae and other vegetation in marine water. The degradation of organic material consumes oxygen, resulting in oxygen deficiency. The impact metric is expressed in kilograms of nitrogen equivalents.

Model: EUTREND (Struijs et al., 2009)

Unit: kg N-eq

Terrestrial eutrophication

This category addresses the impacts from nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilized farmland which accelerate the growth of vegetation in soil. The degradation of organic material consumes oxygen, resulting in oxygen deficiency. The impact metric is expressed in moles of nitrogen equivalents.

Model: Accumulated capitalize exceedance model (Seppälä et al., 2006; Posch et al., 2008)

Unit: mol N-eq

Human toxicity, noncancer effects

This impact category accounts for the potential adverse health effects on humans caused by the intake of toxic substances through inhalation of air, food/water ingestion, and penetration through the skin insofar as they are related to noncancer effects that are not caused by particulate matter or ionizing radiation. The impact metric is expressed in CTUh (comparative toxic units for humans in terms of cases).

Model: USEtox® (Rosenbaum et al., 2008)

Unit: CTUh

Human toxicity, cancer effects

This impact category accounts for the potential adverse health effects on humans caused by the intake of toxic substances through inhalation of air, food/water ingestion, and penetration through the skin insofar as they are related to cancer. The impact metric is expressed in CTUh (comparative toxic units for humans in terms of cases).

Model: USEtox® (Rosenbaum et al., 2008)

Unit: CTUh

Freshwater ecotoxicity

This impact category addresses the potential toxic impacts on freshwater ecosystems. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem. The impact metric is expressed in CTUe (comparative toxic unit for ecosystems in terms of the estimated potentially affected fraction [PAF] of species integrated over volume and time, i.e., PAF*m^3 *y).

Model: USEtox® (Rosenbaum et al., 2008)

Unit: CTUe

Ozone depletion

This impact category accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances; for example, long-lived chlorine and bromine-containing gases (e.g., CFCs, HCFCs, and halons). The emission factors are calculated using ozone depletion potentials (ODP) reported by the World Meteorological Organization (WMO). The ODP is a relative measure for the potency of a substance to destroy the ozone layer. Stratospheric ozone filters out most of the sun's potentially harmful shortwave ultraviolet (UV) radiation. When this ozone becomes depleted, more UV rays reach the earth. Exposure to higher amounts of UV radiation can cause damage to human health.

Model: EDIP based on the ODPs of the WMO with infinite time horizon (WMO 1999)

Unit: kg CFC-11 eq

Particulate matter

This category accounts for the potential impact on human health caused by emissions of particulate matter (PM) smaller than 2.5 micrometers and its precursors (NO_x, SO_x, NH_3) into the air.

Model: PM method recommended by UNEP (UNEP 2016)

Unit: Disease incidence

Photochemical ozone formation

This impact category accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO_x) and sunlight. High concentrations of ground-level tropospheric ozone can damage vegetation, human respiratory tracts, and man-made materials. The impact metric is expressed in kilograms of non-methane volatile organic compounds equivalents (NMVOC).

Model: LOTOS-EUROS (van Zelm et al., 2008)

Unit: kg NMVOC-eq

Resource use, minerals, and metals

This is the indicator of the depletion of natural, nonrenewable resources such as rare minerals and metals. A characterization factor is determined for each type of material based on total reserves and extraction rate; it is normalized to common basis relative to scarcity of antimony metal. The unit is kilograms of antimony equivalents.

Model: CML 2002 (Guinée et al., 2002 and van Oers et al., 2002)

Unit: kg Sb-eq

Resource use, fossils

This is the indicator of the depletion of natural, nonrenewable fossil fuel resources such as crude oil, coal, and natural gas. This impact indicator accounts for extraction of fossil materials for use as both fuels and feedstocks. Characterization factors are determined for each type of fossil resource based on its extraction rate and the ultimate reserves in the earth. The unit is megajoules (MJ) of energy.

Model: CML 2002 (Guinée et al., 2002 and van Oers et al., 2002)

Unit: MJ

Water scarcity footprint

This impact indicator assesses the potential of water deprivation. It builds on the assumption that, the less water remaining available per area, the more likely another user will be deprived. It is based on the AWARE (Available WAter REmaining) model, the recommended method from WULCA for water consumption impact assessment in LCA.

Model: AWARE 100 (Boulay et al., 2016)

Unit: m^3 world eq

Interpretation of human toxicity and ecotoxicity indicators

Assessing toxicity impact through LCA methodologies is a less developed science. Special caution is needed when interpreting LCIA results for human toxicity and ecotoxicity. Compared with impact categories such as GWP and AP, the assessment of toxicity in LCA can be highly uncertain due to data gaps, methodological limitations, and discrepancies between methodologies.

Nonetheless, toxicity indicators have been included in this study for the sake of completeness and relevance. LCI assessment of human toxicity and ecotoxicity is based on modeling and does not involve any actual testing on people or animals. As such, human and ecosystem toxicity impacts in an LCA are classified as robustness level III (vs. level II or I). The human health and ecotoxicity indicators are based on the USEtox consensus model, which estimates exposure to emissions. USEtox attempts to integrate the impact of toxic emissions into an LCA as a complement to other, better-proven tools such as risk assessment, environmental impact assessment, and health and safety regulations for product level, workplace, and local environments. It is not intended to predict any specific impacts to human or ecological health, such as cases of cancer.

Eastman, however, is committed to the safe manufacture and use of its products, as demonstrated by our participation in key initiatives such as Responsible Care and compliance with all applicable regulatory requirements, including Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

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