ENVIRONMENTAL PRODUCT DECLARATION

FLOAT GLASS

GUARDIAN GLASS
AME & I REGION

Guardian Glass is dedicated to continually improving the science and process of its core competency, float glass manufacturing.

This EPD was not written to support comparative assertions. Even for similar products, differences in declared unit, use and end-of-life stage assumptions and data quality may produce incomparable results. It is not recommended to compare EPDs with another organization, as there may be differences in methodology, assumptions, allocation methods, data quality such as variability in data sets and results of variability in assessment software tool.

Guardian Glass is committed to the efficient use of natural resources while operating in a way that protects the safety, health and well-being of its employees, customers, the environment and society.

As a manufacturing leader of high performance, energy-efficient glass products for commercial, residential, interior, transportation and specialty applications, Guardian Glass makes products that help improve people's lives. By allowing abundant natural light into homes, offices and vehicles, glass products can help contribute to occupant's well-being and low-emissivity glass reduces energy consumption for heating and cooling.

By publishing this EPD, Guardian Glass intends to support architects and designers who strive to enhance the sustainability profiles of the buildings they design through the products they specify. The goal is to provide them with the information needed to achieve credits in global green building rating systems.

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This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Gujarat Guardian Limited
DECLARATION NUMBER	4788827138.101.1
DECLARED PRODUCT	Guardian Float Glass
REFERENCE PCR	NSF International GANA PCR for Flat Glass: UN CPC 3711
REFERENCE PCR STANDARD	☐ EN 15804 (2012) ☒ ISO 21930 (2007) ☐ ISO 21930 (2017)
DATE OF ISSUE	July 1, 2020
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications

The PCR review was conducted by:	NSF International PCR Review Panel ncss@nsf.org
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas Gloria Thomas Gloria, Industrial Ecology Consultants

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Product System

Company Description

Guardian Industries, a global company headquartered in Auburn Hills, Michigan, employs 18,000 people and operates facilities throughout North America, Europe, South America, Africa, Middle East and Asia.

Guardian Glass is the go-to solutions provider for the global glass industry, whether you want to solve a practical problem or challenge architectural conventions. With the infrastructure, know-how and capability to work with the entire supply chain, we are ready to embrace a future where glass is an even greater part of what the world builds. We are here to help you realize your vision, overcome obstacles and be partners in your progress.

We are one of the world's largest glass manufacturers with leading positions in float and fabricated glass products for commercial, residential, interior, technical and transportation applications. We aim to create value for our customers and society and to constantly innovate to improve the value we create.

We also pride ourselves on creating a work environment that recognizes and celebrates individuality, teamwork and success. The foundation of our culture rests upon our Guiding Principles. Our entrepreneurial spirit encourages employees to think bigger and creates opportunities to learn from and collaborate with very skilled and knowledgeable mentors. Award-winning scientists and engineers at our Science & Technology Center are constantly working to create new glass products and solutions using the most advanced technologies.

Guardian Glass is part of Guardian Industries, a wholly owned subsidiary of Koch Industries, Inc. Koch companies conduct their worldwide operations in compliance with all relevant environmental laws and regulations, while protecting the health and safety of their customers, employees and neighbors. In 2017, Koch was awarded the U.S. Environmental Protection Agency's ENERGY STAR Partner of the Year Award.

Product Description

This EPD is valid for the following float unprocessed Guardian Glass product:

- Clear Float Glass
- Ultra Clear™ Low-Iron Glass

For more information about these products, please visit www.guardianglass.com or email info@guardianglass.com

Application

Float glass products are used in applications ranging from equipment components to transportation vehicles and architectural products. Guardian glass supplies float glass to customers who further process that glass into the final product by cutting, heat-treating, laminating, insulating or otherwise fabricating the glass into the desired size and makeup for use in the intended application. The glass make up is typically specified by architects, glazing contractors, window manufacturers and other design professionals.

Technical Data

Technical data on Guardian float glass products is available on at www.guardianglass.com

Technical data on MODIGUARD® float glass product is available on at www.gujaratguardianglass.com

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Properties of Declared Product as Delivered

Product sizes: While products are primarily cut to customers' specified dimensions, common dimension of float glass include:

- 1220 mm x 1830 mm
- 1830 mm x 2440 mm
- 2250 mm x 3210 mm
- 2440 mm x 3660 mm
- 3210 mm x 5100 mm
- 3210 mm x 6000 mm

While thickness of the glass also varies based on customer needs, some standard thicknesses for float glass includes:

- 2 mm	- 2.5 mm	- 3 mm	- 3.5 mm
- 4 mm	- 5 mm	- 6 mm	- 8 mm
- 10 mm	- 12 mm	- 15 mm	

Declaration Type:	Business-to-business
Period of Validity:	5 years
Geographic Scope:	This EPD is valid for float glass products sold in Africa, Middle East & India (AME & I) from Guardian Glass.
Additional Notes:	Further processing of float glass like coating, tempering, laminating etc are beyond the scope of this EPD. This EPD is based on production data of float glass for 2018 collected from Guardian Glass plants located in Egypt, Saudi Arabia, UAE & India.

Placing on the Market

The products validated in this EPD conform to JIS R 3202, EN 572-2, ISO 16293-2, IS 14900, AS/NZS 4667, SASO 1916, ASTM C 1036, ES 353, TCVN 7218, KS 1535-1 & 2, TIS 880 Standards specifies the float glass used for building and other various applications.

Product Formulation

Float glass is manufactured from raw materials such as silica sand, soda ash, dolomite, limestone and cullet. The crystalline raw materials chemically and structurally transform into amorphous glass through a fusion (melting) process, thereby producing a product which is >99.9% glass oxide.

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Manufacture

Float glass production involves heating the raw materials to a molten state and then floating the subsequent ribbon of glass atop a bath of molten tin. Once the ribbon has sufficiently cooled, it is transferred onto rollers and annealed to limit residual stresses. Its edges are trimmed and the ribbon is cut to the desired sizes. The finished float glass products are stored for additional processing (e.g., heat-treating or coating) or directly packaged and shipped to customers.

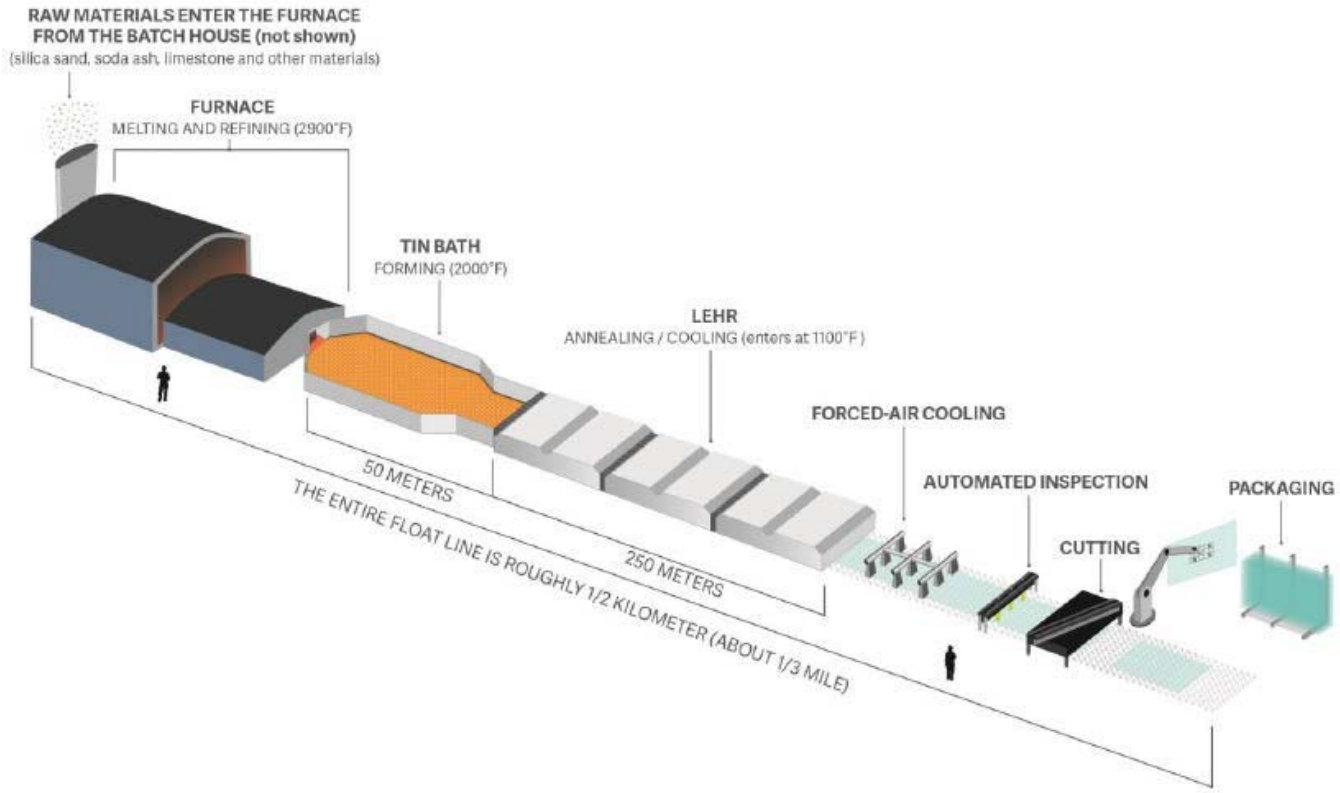

Figure 1: Float Glass Production

Manufacturing of 'Float Glass' product in AME & I region is done at Guardian facilities as Guardian Egypt, "Egypt"; Saudi Guardian International Float Glass Ltd, "Saudi Arabia"; Guardian Zoujaj International Float Glass Co. L.L.C, "United Arab Emirates" & Gujarat Guardian Ltd, "India".

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Environment and Health during Manufacturing

Guardian Glass implements measures to reduce waste and reuse/recycle materials internally within its manufacturing processes. Consistent with industry practice, batch ingredients include “cullet”, broken glass from prior in-plant ribbon-trimming operations and other potential sources. A limited amount of cullet from outside plant is accepted after stringent quality checks. The use of cullet helps to moderate consumption of batch materials and furnace fuels, both affecting carbon dioxide (CO_2) emissions.

Guardian Glass benefits from recycling in several ways. Although never 100% recycled, the recycled glass used reduces CO_2 process emissions and consumption of virgin raw materials; extends the life of plant equipment (such as furnaces); and saves energy. Recycled glass is part of the recipe for glass, and the more that is used, the greater the decrease in energy used in the furnace. This makes using recycled glass profitable in the long run — lowering costs and benefiting the environment while ensuring greater product sustainability without negatively impacting quality.

Product Processing / Installation

Guardian Glass products should be processed and installed according to best industry standards and according to all applicable building codes in the given jurisdiction.

Packaging, Handling and Storage

Guardian Glass products in the AMEI region are primarily packaged or boxed in wooden crates and handled through the use of forklifts & cranes with spreader bar/box lifting booms & pack lifters. Open glass packs are typically stored with polystryene foam or rubber used as a separator and handled with forklifts or cranes with nylon salings or side loaders. Various types of racks are used for storage in the warehouse with glass shipped to the customers utilizing trucks & containers.

For all handling and storage related activities, extreme care is required as the greatest risks are lacerations from cut/broken glass and injury from falling glass. Due to the risk of serious injuries as a result of improper handling and transportation, it is imperative that all persons involved in the handling and storage of glass receive proper training, wear adequate personal protective equipment and adhere to all best handling and safety procedures.

Conditions of Use

Float glass products are used in applications ranging from equipment components to transportation vehicles and architectural products. Guardian Glass typically supplies float glass and coated glass to fabricator customers who further process that glass into the final product by cutting, heat-treating, laminating, insulating or otherwise fabricating the glass into the desired size and makeup for use in the intended application.

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Environment and Health during use

The life cycle assessment is conducted for a cradle-to-gate system boundary, per NSF GANA Product Category Rule (PCR) for Flat Glass — UN CPC 3711. Life cycle stages and environmental impacts downstream of Guardian's North America float glass facilities are not included in this declaration. Additionally, transportation to waste or scrap facilities is excluded from the system, as are capital goods, infrastructure, and personnel-related activities.

Reference Service Life

Guardian float glass products satisfy the 30-year service life requirement as defined by the Glass Association of North America (GANA) Product Category Rule (PCR) for Float Glass.

Distribution, Use, and End of Life

Upon leaving Guardian Glass facilities, float glass can be further processed through a regional network of independent fabricators. Racks used for distribution of glass are reused many times both in the manufacturing plants and shipped to the customer and returned to Guardian Glass plants. Glass should be installed according to industry standards and according to all applicable building codes in the given jurisdiction. Glass should be washed frequently to remove surface dirt and to protect the glass from staining. Glass staining occurs when the sodium within the glass reacts with moisture in the air. Sodium, when combined with small amounts of water, can create sodium hydroxide, which is corrosive to glass. Once installed, Guardian Glass products do not consume energy or require maintenance beyond general cleaning to fulfill their estimated service life. At end-of-life, glass is typically landfilled and, in some instances, recycled.

Further Information

Further information about Guardian Glass products is available at www.guardianglass.com

Further information about MODIGUARD® products is available at www.gujaratguardianglass.com

LCA Calculation Rules

Declared Unit

Attributional approach has been taken in this study and the declared unit is 1 metric tonne of float glass, maintained for a period of 30 years. As Guardian's float glass has an estimated service life of more than 30 years, this EPD represents one ton of float glass.

Name	Unit	Float Glass
Declared unit	metric tonne	1
Thickness	mm	4
Area Covered by Declared Unit	mm	100

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System Boundary

The reference product as per PCR ["GANA PCR for Flat Glass: UN CPC 3711"] is 'Float Glass'. As per this PCR environmental impcts from raw material extraction and energy flows, float glass manufacture, packaging and storage are to be calculated. The PCR does not include distribution, use phase and end of life phase. Also capital goods, infrastructure, personnel-related activities, waste treatment facilities etc are not included in EPD.

Raw materials like silica sand, soda ash, limestone, dolomite, feldspar, sodium sulphate etc are procured from suppliers and brought to production facility through in-bound transportation. These raw materials are converted into finished product 'Float Glass' at Guardian's manufacturing plants. The finished product is packed and stored for delivery.

Estimates and Assumptions

Due to limitations in data availability, assumptions were made in selection of appropriate processes for manufacturing inputs like materials, natural gas, electricity and facility emissions. The allocation approaches taken may, therefore, overestimate the environmental burden for float glass production.

Additionally, the "average" glass pane used in modeling is a calculated average pane thickness and area and does not a specific product manufactured by Guardian Glass.

Background Data

Regional and national avaerages for fuel inputs, electricity grid mixes, materials, transportation, and disposal methods were obtained from the GaBi (2019) Service Pack 37 database. Documentation for all Gabi datasets can be found at www.gabi-software.com/international/databases/gabi-databases/.

Raw Material Composition of Float Glass

The raw material composition for the 'Float Glass' product is shown below. Data captured here are approximate.

Sl. No.	Raw Materials	Weight (kg/metric tonne)	% of total Weight
1	Silica Sand (Sand)	400 - 600	40 - 60
2	Soda Ash	100 - 200	10 - 20
3	Limestone	10 - 100	1 - 10
4	Dolomite	100 - 200	10 - 20
5	Feldspar	< 50	< 5
6	Salt Cake	< 20	< 2
7	Cullet	150 - 250	15 - 25
8	Carbon (Charcoal)	< 1	< 0.1

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Data Quality

A number of tests and checks were performed throughout the project to ensure the high quality of the completed LCA. Checks included relevance of selected processes, review of LCA model as well as the background data used.

Data included first-hand company manufacturing data in combination with consistent background LCI information from the Gabi 2019 databases.

Period Under review

The data are representative of production at Guardian Egypt, Egypt; Saudi Guardian International Float Glass Ltd, Saudi Arabia; Guardian Zoujaj International Float Glass Co. L.L.C "Guardian RAK", U.A.E and Gujarat Guardian Ltd, India; for the 2018 calender year.

Allocation

Allocation by mass has been consistently used in this study. Allocation by mass has been used to model float glass and glass cullet. No material was sent off site for recycling.

Cut-Off Rules

Mass and energy flows having less than 1% environmental burden are not considered in this study. Flocculant [SNF5640] used for washing, LPG, transportation of water, oxygen, nitrogen, hydrogen through pipeline from a very short distance etc have not been considered. No known flows are deliberately excluded from this EPD.

LCA: Results

As per the guidelines of the PCR, life cycle impact results have been calculated for cradle-to-gate phase. Gate-to-grave phase impacts are not required as per PCR, thus have not been calculated.

The PCR also mandates to sort the energy consumption, wastes, emissions, etc per declared unit, which is 1 metric tonne of float glass of 4 mm thickness by life cycle stages and in total.

Impact assessment categories also need to be reported by different life cycle stages and in total. The PCR does not require reporting of human health and eco-toxicity due to their uncertainty.

Energy consumption for 1 metric tonne of Float Glass of 4 mm thickness

Energy Type	Unit	A1. Raw Materials	A2. Raw Material Transport	A3. Manufacturing	A1 – A3 Total
Non renewable primary energy demand, fossil	MJ	3.78E+03	9.71E+02	1.13E+04	1.60E+04
Non renewable primary energy demand, nuclear	MJ	3.29E+02	4.43E+00	3.36E+01	3.67E+02
Non renewable primary energy demand, total	MJ	4.11E+03	9.76E+02	1.13E+04	1.64E+04
Renewable primary energy	MJ	5.06E+02	1.00E+00	4.50E+01	5.52E+02

demand, solar					
Renewable primary energy demand, wind	MJ	2.15E+02	4.05E-01	5.07E+02	7.22E+02
Renewable primary energy demand, hydro	MJ	4.54E+01	1.23E+00	7.67E+01	1.23E+02
Renewable primary energy demand , biomass	MJ	3.78E-16	-	6.75E-09	6.75E-09
Renewable primary energy demand, geothermal	MJ	7.28E-01	1.88E-03	1.29E+01	1.37E+01
Renewable primary energy demand, total	MJ	7.66E+02	2.64E+00	6.41E+02	1.41E+03
Miscellaneous Fuels	MJ	-	-	-	-

Wastes for 1 metric tonne of Float Glass of 4 mm thickness

Parameter	Unit	A1. Raw Materials	A2. Raw Material Transport	A3. Manufacturing	A1 – A3 Total
Incineration with energy Recovery	kg	-	-	-	-
Incineration without energy Recovery	kg	-	-	-	-
Hazardous waste	kg	1.78E-05	7.29E-08	2.93E-06	2.08E-05
Non-Hazardous waste	kg	1.35E+03	1.08E+00	2.98E+02	1.65E+03

Emissions to air and water for 1 metric tonne of Float Glass of 4 mm thickness

Parameter	Unit	A1. Raw Materials	A2. Raw Material Transport	A3. Manufacturing	A1 – A3 Total
Emissions to Air					
Sulfur Oxides (SOx)	kg	4.13E-01	6.51E-02	1.74E+00	2.22E+00
Nitrogen Oxides (NOx)	kg	8.10E-01	1.23E+00	3.25E+00	5.29E+00
Carbon Dioxide (CO_2e)	kg	3.20E+02	6.92E+01	7.60E+02	1.15E+03
Carbon Monoxide (CO)	kg	1.24E+00	2.50E-01	1.80E-01	1.67E+00
Water Usage and Emissions to Water					
BOD	kg	2.11E-03	6.33E-03	2.40E-03	1.08E-02
TDS	kg	7.78E-03	1.53E+00	-1.18E-03	1.54E+00

TSS	kg	9.49E+00	1.30E-01	4.10E-01	1.00E+01
Use of net fresh water	m^3	1.31E+00	1.09E-02	8.59E-01	2.18E+00

Life Cycle stages and Total impacts for 1 metric tonne of Float Glass of 4 mm thickness [TRACI Impact Assessment Methodology]

Impact category	Unit	A1. Raw Materials	A2. Raw Material Transport	A3. Manufacturing	A1 – A3 Total
Ozone Depletion Potential	kg CFC-11 eq	7.32E-11	1.26E-09	-8.76E-11	1.24E-09
Global Warming Potential	kg CO2 eq	3.37E+02	7.32E+01	8.14E+02	1.22E+03
Photochemical Ozone Creation Potential	kg O3 eq	2.04E+01	2.73E+01	8.09E+1	1.29E+02
Acidification Potential	kg SO2 eq	1.64E+00	9.27E-01	4.06E+00	6.63E+00
Eutrophication Potential	kg N eq	1.76E-01	5.64E-02	1.60E-01	3.93E-01
Mineral Resource Depletion Potential	kg Fe eq	1.20E+00	1.91E-02	2.18E+00	3.39E+00

The raw materials and processing phase account for ~ 6 % of total impacts for Ozone Depletion, ~28% for Global Warming, ~16% for Photochemical Ozone Creation Potential or Smog, ~25% for Acidification, ~37% for Eutrophication and ~35% for Mineral Resource depletion potential.

5 impact categories of TRACI 2.1 were calculated with CML-1A method also. Photochemical ozone creation potential is measured in kg C2H4 -eq in CML-1A and in TRACI 2.1 smog is measured in kg O3 eq. These may account for difference in total impacts. Same is the case for eutrophication. The other three impact cateories vary marginally.

LCA Interpretation

The cradle-to-gate impact assessment results graph for one metric tonne of float glass of 4 mm thickness is shown below.

The results are broken down into different phases and major impact generators for clear and precise information about sources of impacts.

Raw Materials: Raw materials account for 45% of the eutrophication impact. The raw materials phase makes up 15-35% of the other phases, with the exception of ozone depletion potential (6%)

Raw Material Transport: Sea transport and road transport are extensively used since all the raw materials are outsourced. This explains the high contribution to ozone depletion potential (94%). Other impact categories with noticed effects are the photochemical ozone creation, acidification, and eutrophication potentials.

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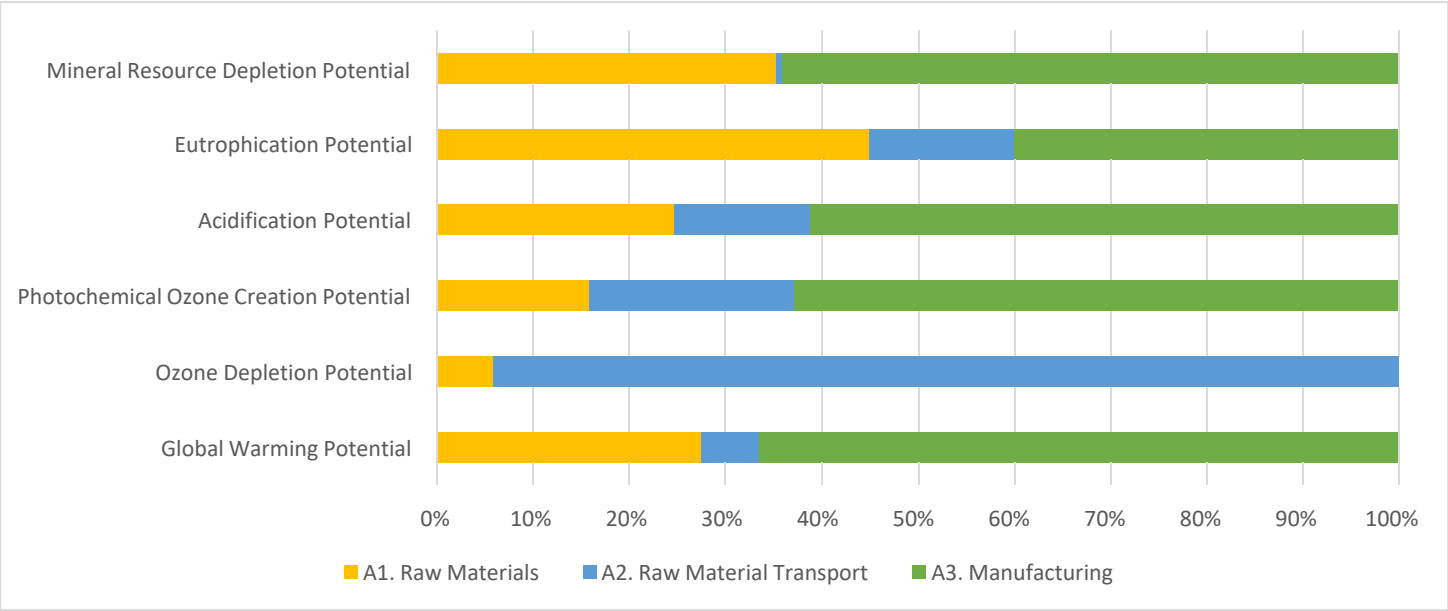

Manufacturing: Materials like silica sand, dolomite, soda ash, oxygen, nitrogen, hydrogen, tin, etc are used in this phase. This explains around 60% contribution to mineral resource depletion potential. The impacts of manufacturing on the acidifcation, smog, and global warming potential categories range from 61-66%.

Additional Environmental Information

Glass is by nature an inert material that does not release volatile organic compound (VOCs). There are no VOCs present in finished uncoated, tinted or patterned float glass products. Float glass may contain the contaminants chromium, cadmium, and/or lead (present as impurities at very low concentrations in mined raw materials such as silica or limestone) at concentrations well below the threshold limits for EU RoHS. These substances are the only RoHS hazardous substances that have the potential to be in the glass (typically undetected or in the parts per billion range). These substances are not intentionally added to the glass during the manufacturing process. Float glass is not classified as toxic, has no known hazardous decomposition products. Float glass is not classified as flammable or combustible per EU Regulation (EC) No. 1272/2008. Float glass will not pose an exposure hazard under the intended conditions of use. However, sanding, grinding, or similar activities can create nuisance dust particles.

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