LOTTE ADVANCED MATERIALS

VERIFIED by SCS GLOBAL SERVICES ENVIRONMENTAL PRODUCT DECLARATION BASED ON LCA

Declaration Owner

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Products

Radianz® Quartz Surfaces

Functional Unit

The functional unit is one square meter of countertop provided and maintained for a period of 10 years in residential use.

EPD Number and Period of Validity

SCS-EPD-04750
EPD Valid November 20, 2017 through November 19, 2022

Product Category Rule

Product Category Rule for Environmental Product Declarations: *PCR for Residential Countertops*. NSF International. Valid through September 17, 2018.

Program Operator

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SCSglobal SERVICES

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Disclaimers: *This EPD conforms to ISO 14025, 14040, and ISO 14044.*

Scope of Results Reported: *The PCR requirements limit the scope of the LCA metrics such that the results exclude environmental and social performance benchmarks and thresholds, and exclude impacts from the depletion of natural resources, land use ecological impacts, ocean impacts related to greenhouse gas emissions, risks from hazardous wastes and impacts linked to hazardous chemical emissions.*

Accuracy of Results: *Due to PCR constraints, this EPD provides estimations of potential impacts that are inherently limited in terms of accuracy.*

Comparability: *The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.*

PCR review, was conducted by	Evan Griffing, PhD, Environmental Clarity LLC, egriffing@environmentalclarity.com
Approved Date: November 20, 2017 – End Date: November 19, 2022	
Independent verification of the declaration and data, according to ISO 14025:2006	☐ internal ☑ external
Third party verifier	Tom Gloria, Ph.D., Industrial Ecology Consultants

ABOUT LOTTE

Lotte Advanced Materials Co., Ltd., formerly Cheil Industries, established in 1954 as the founding parent company of the Samsung Group, kicked off its chemical business as part of its portfolio expansion strategy. In 1992, the company started its solid surface business and in 2009 made a foray into manufacturing of engineered stone (quartz surfaces) in a move to strengthen its business portfolio further. In May 2016, the company was renamed as Lotte Advanced Materials, a move forward toward achieving a greater vision of becoming a global supplier of high-quality, decorative surfacing materials.

PRODUCT DESCRIPTIONS

Radianz® Quartz Surfaces is comprised of natural quartz, unsaturated polyester resins, and mineral pigments fused together by a precision compression molding process to create a high-quality product. Natural quartz, with purity of 99.9%, is the main component that results in a non-porous and ultra-durable material that is ideal for countertops, kitchen systems, furniture, wallcladding and various other interior finishes for residential and commercial applications. In accordance with the PCR, the product is classified as engineered stone countertop. The countertop product includes 2.9% pre-consumer recycled content. The manufacturer warrants for a period of 10 years from the date of purchase.

PRODUCT CHARACTERISTICS AND PERFORMANCE

Table 1. *Product characteristics for Radianz® Quartz Surfaces.*

Characteristic	Nominal Value	Unit
Slab thickness	30 (1.2)	mm (inch)
Slab length	3,100 (122)	mm (inch)
Slab width	1,520 (60)	mm (inch)
Slab weight	74.9 (15.3)	kg/m^2 (lb/ft^2)
Underlayment included	N	Y/N
VOC Emissions Test Method	GREENGUARD Gold	-

Table 2. *Product performance test results for Radianz® Quartz Surfaces.*

Properties	Results	Test Method
Specific Gravity	2.41	ASTM D792-08
Water Absorption	0.03%	ASTM C373-06
Coefficient of Linear Thermal Expansion	1.35 x 10-5 / °C	ASTM D696-03
Flexural Strength	53.6 Mpa	ASTM D790-07
Flexural Modulus	11.9 Gpa	ASTM D790-07
Boiling Water Resistance	No effect	NEMA LD3 2000 3.5
High Temperature	No effect	NEMA LD3 2000 3.6
Moh's Hardness	7	MOHS Hardness Scale
Slip Resistance – Coefficient of Friction (Received: Dry/Wet)	0.91 / 0.49 0.45 / 0.57 1.03 / 0.49	ASTM C1028-07
Slip Resistance – Coefficient of Friction (Renovated: Dry/Wet)	0.89 / 0.48 0.40 / 0.58 0.92 / 0.50	ASTM C1028-07
Compressive Strength	DRY: 213.74 WET 251.16 Mpa	ASTM C170-09
Stain Resistance	Passes	ANSI Z124.6-07
Cigarette Test	Passes	ANSI Z124.6-07
Chemical Resistance	Passes	ANSI Z124.6-07
Impact Tests	Passes	ANSI Z124.6-07
Fungal Resistance	No effect	ASTM G21-96
Bacteria Resistance	No effect	ASTM G22-96
Rockwell Hardness	114	ASTM D785-03
Abrasion Resistance	606mg	ASTM D4060-07
Flammability	Class A	ASTM E84-09

MATERIAL COMPOSITION

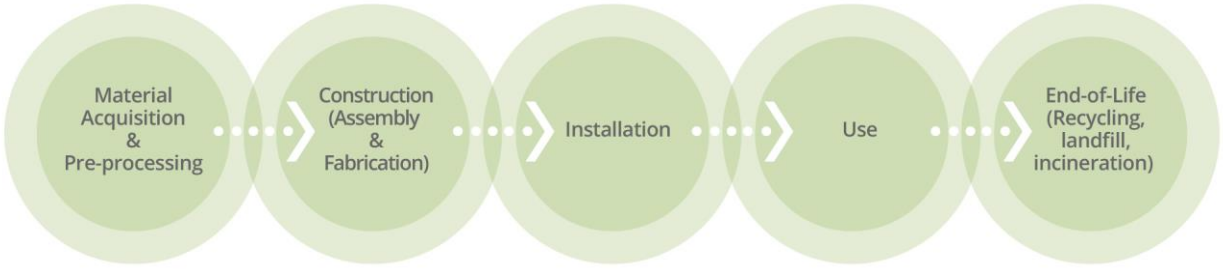
Table 3. *Material composition of Radianz® Quartz Surfaces in kilograms per functional unit and in percentage of total weight.*

Material	Amount in Final Product (kg/m²)	Percent of Total (%)	Material Resources Type
Product			
Quartz	63.6	85.0%	Virgin non-renewable
Unsatured polyester	6.48	8.65%	Virgin non-renewable
Additives (unspecified)	2.34	3.12%	Virgin non-renewable
Recycled glass*	2.14	2.86%	Recycled non-renewable
Titanium dioxide	0.225	0.300%	Virgin non-renewable
Additive (TBPB)	0.0989	0.120%	Virgin non-renewable
Total	74.9	100%	-
Packaging			
Protection film (LDPE)	0.060	4.55%	Virgin non-renewable
Wood pallet	1.26	95.5%	Virgin renewable
Total	1.32	100%	-

*100% pre-consumer recycled content

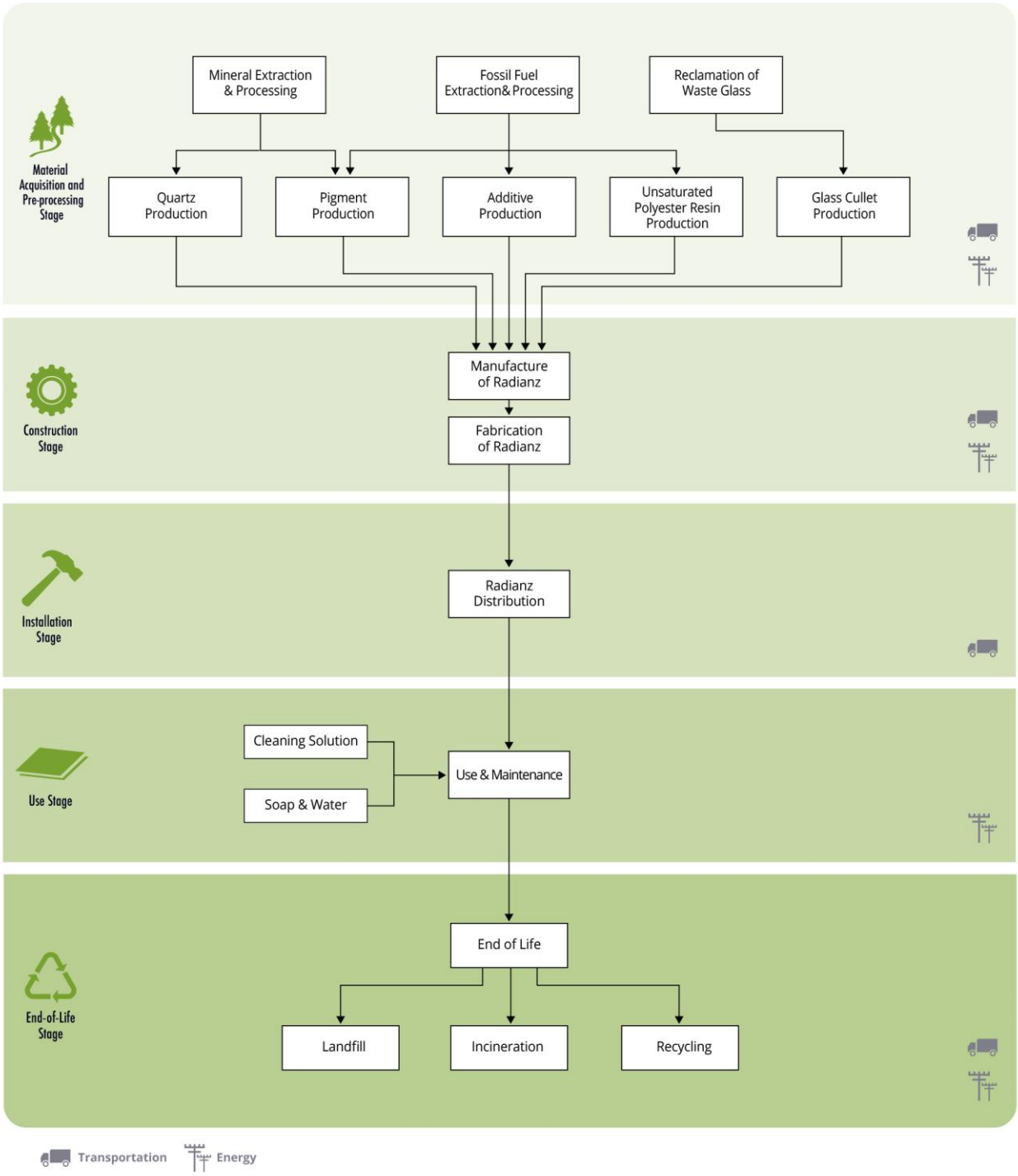
LIFE CYCLE ASSESSMENT STAGES

A cradle to grave life cycle assessment (LCA) was completed for this product in accordance with ISO 14040, ISO 14044, and the Product Category Rule for Environmental Product Declarations: *PCR for Residential Countertops*. The diagram below illustrates the life cycle stages included in this EPD.



PRODUCT LIFE CYCLE FLOW DIAGRAM

The diagrams below are a representation of the most significant contributions to the life cycle of Radianz® Quartz Surfaces. This includes material acquisition and pre-processing, construction (assembly and fabrication), installation, use, and end-of-life.



LIFE CYCLE INVENTORY

The life cycle inventory (LCI) flows for the EPD are shown in Table 4 in accordance with the requirements of the PCR. Water usage from electricity generation is included.

Table 4. *Life cycle inventory flows for 1 m^2 Radianz® Quartz Surfaces provided and maintained for a period of 10 years.*

Parameter	Total	Material Acquisition & Pre-processing	Construction	Installation	Use	End-of-Life
Emissions to Air (kg)						
SO_X	0.46	0.21	0.21	$2.1x10^{-2}$	$7.8x10^{-3}$	$4.6x10^{-3}$
NO_X	0.56	0.15	0.32	$6.2x10^{-2}$	$1.0x10^{-2}$	$2.0x10^{-2}$
CO_2	133	53	55	14	8.7	2.8
Methane	0.37	0.27	$8.4x10^{-2}$	$1.3x10^{-2}$	$9.1x10^{-3}$	$2.7x10^{-3}$
N_2O	$8.9x10^{-2}$	$8.4x10^{-2}$	$1.4x10^{-3}$	$2.9x10^{-4}$	$2.6x10^{-3}$	$1.2x10^{-4}$
CO	0.40	0.18	0.13	$3.0x10^{-2}$	$5.0x10^{-2}$	$9.0x10^{-3}$
Water Usage and Emission to Water (kg)						
Water Consumption	7,800	4,400	2,200	160	940	37
Phosphates	0.11	$5.4x10^{-2}$	$4.8x10^{-2}$	$3.4x10^{-3}$	$2.9x10^{-3}$	$4.0x10^{-4}$
Nitrates	0.19	$1.8x10^{-2}$	$1.7x10^{-2}$	$1.1x10^{-3}$	0.16	$1.4x10^{-4}$
Dioxin	0.0	0.0	0.0	0.0	0.0	0.0
Arsenic	$2.4x10^{-4}$	$1.3x10^{-4}$	$8.6x10^{-5}$	$1.2x10^{-5}$	$7.6x10^{-6}$	$1.1x10^{-6}$
Lead	$1.1x10^{-3}$	$1.2x10^{-4}$	$9.9x10^{-4}$	$1.2x10^{-5}$	$8.2x10^{-6}$	$1.8x10^{-6}$
Mercury	$1.0x10^{-5}$	$4.1x10^{-6}$	$5.4x10^{-6}$	$2.5x10^{-7}$	$3.0x10^{-7}$	$3.3x10^{-8}$
Cadmium	$2.6x10^{-4}$	$6.0x10^{-5}$	$1.9x10^{-4}$	$5.2x10^{-6}$	$3.9x10^{-6}$	$1.8x10^{-6}$
Chromium	$5.7x10^{-4}$	$2.6x10^{-4}$	$2.5x10^{-4}$	$3.8x10^{-5}$	$2.2x10^{-5}$	$3.9x10^{-6}$
Energy Type and Usages (MJ)						
Primary energy demand	2,700	1,400	930	240	100	53
Fossil fuels	2,400	1,300	790	230	28	52
Nuclear	180	72	100	3.7	2.2	0.50
Renewable*	150	45	33	2.8	72	0.56
Waste Management (kg)						
Incineration with energy recovery	INA	INA	INA	INA	INA	INA
Incineration without energy recovery	INA	INA	INA	INA	INA	INA
Landfill (Non-hazardous waste)	140	6.6	20	10	0.76	100
Hazardous waste	$3.8x10^{-3}$	$8.2x10^{-4}$	$2.7x10^{-3}$	$1.3x10^{-4}$	$5.1x10^{-5}$	$2.2x10^{-5}$
Landfill avoidance (recycling)	1.8	Negligible	1.8	Negligible	Negligible	Negligible

*Solar, wind, hydro, biomass

INA = Indicator not assessed

LIFE CYCLE IMPACT ASSESSMENT

The life cycle impact assessment (LCIA) for the EPD is conducted in accordance with requirements of the PCR. Impact category indicators are estimated using the TRACI 2.1 and CML characterization methods. The LCIA results are calculated using SimaPro 8.3 software.

Table 5. *LCIA results for 1 m^2 Radianz® Quartz Surfaces provided and maintained for a period of 10 years.*

Impact Category	Units	Total	Material Acquisition & Pre-processing	Construction	Installation	Use	End-of-Life
Global warming potential	kg CO_2 eq	170	84	58	14	10	2.9
		100%	50%	34%	8.5%	5.7%	1.7%
Acidification potential	kg SO_2 eq	0.89	0.32	0.45	$6.5x10^{-2}$	$2.7x10^{-2}$	$1.8x10^{-2}$
		100%	37%	51%	7.4%	3.0%	2.1%
Photochemical ozone creation potential	kg O_3 eq	14	3.9	7.9	1.5	0.31	0.49
		100%	28%	56%	11%	2.2%	3.4%
Eutrophication potential	kg N eq	0.46	0.21	0.18	$1.6x10^{-2}$	$5.3x10^{-2}$	$3.5x10^{-3}$
		100%	45%	39%	3.5%	12%	0.78%
Ozone depletion potential	kg CFC-11 eq	$2.3x10^{-5}$	$8.6x10^{-6}$	$9.8x10^{-6}$	3.5E-06	$3.7x10^{-7}$	$8.1x10^{-7}$
		100%	37%	42%	15%	1.6%	3.5%
Abiotic depletion potential (elements)*	kg Sb eq	$3.5x10^{-4}$	$2.0x10^{-4}$	$8.6x10^{-5}$	$4.2x10^{-5}$	$1.6x10^{-5}$	$2.2x10^{-6}$
		100%	58%	25%	12%	4.5%	0.63%
Abiotic depletion potential (fossil fuels)	MJ	2,400	1,300	790	230	27	52
		100%	53%	34%	10%	1.2%	2.2%

* This indicator is based on assumptions regarding current reserves estimates. Users should use caution when interpreting results because there is insufficient information on which indicator is best for assessing the depletion of abiotic resources.

ADDITIONAL ENVIRONMENTAL INFORMATION

Lotte Advanced Materials Co., Ltd. is certified to ISO 14001:2009 Environmental Management System and is committed to managing environmental impact by improving environmental performance, cutting waste, and reducing costs without compromising performance. To view the certification, please visit: https://www.staron.com/File/download.do?fileName=1489377807825.pdf

There are no heavy metals or toxic chemicals used in the production of Radianz®. All suppliers of the raw materials used in the manufacture of Radianz® are supervised under a strict Lotte quality control program. Materials are inspected by both internal/external examining bodies for compliance with RoHS (Restricting the use of Hazardous Substances) and NSF (National Sanitation Foundation, USA) ensuring that Radianz® manufacturing meets the environmental standards required. For more information, please visit the published Health Product Declaration (HPD): https://www.staron.com/File/download.do?fileName=1489377735432.pdf

Lotte Advanced Materials Co., Ltd. is certified to ISO 50001: 2011 and follows a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use, and consumption. To view the certification, please visit: https://www.staron.com/File/download.do?fileName=1489377632329.pdf

Lotte Advanced Materials Co., Ltd. is certified to ISO 9001: 2009 and therefore conforms to high quality management principles to ensure their products consistently meet customers' requirements, and that quality is consistently improved. To view the certification, please visit: https://www.staron.com/File/download.do?fileName=1489377775677.pdf

Scrap and waste generated during the production process are recycled and re-used in the manufacture of new products. Radianz® recycled series products are manufactured using pre-consumer recycled content and are certified by SCS Global Services that can contribute to LEED® v4 MR Credits for Building Product Disclosure and Optimization – Sourcing of Raw Materials, option 2, resulting in a reduction of industrial waste and energy consumption during the manufacturing process. Using recycled content helps conserve energy and resources, alleviates pressure on landfill space and reduces the need for transportation during certain phases of a product's life cycle.

Radianz® is GREENGUARD Gold certified and is therefore scientifically proven to meet some of the world's most rigorous, third-party chemical emission standards – helping reduce indoor air pollution and the risk of chemical exposure while aiding in the creation of healthier indoor environments. GREENGUARD Gold certification standard includes health based criteria for additional chemicals and also requires lower total VOC (volatile organic compounds) emissions levels to ensure products are acceptable for use in environments such as schools and healthcare facilities. To view the certification, please visit: https://www.staron.com/File/download.do?fileName=1507769335229.pdf

Radianz® received a Certificate of Environmental Building Material (Certificate #: HB916G09-01) and achieved an outstanding grade in accordance with the regulation for environmental building materials provided by the Korea Air Cleaning Association.

SUPPORTING TECHNICAL INFORMATION

Unit processes are developed with SimaPro 8.3 software, drawing upon data from multiple sources. Primary data were provided by Lotte for their manufacturing, upstream transport, and distribution processes. The primary sources of secondary LCI data are from Ecoinvent.

Table 6. *LCI datasets and associated databases used to model the Radianz® Quartz Surfaces product system.*

Flow	Dataset	Data Source	Publication Date
Radianz Materials			
Quartz	Silica sand {RoW}| production | Alloc Rec, U	Ecoinvent	2016
Unsatured polyester	Polyester resin, unsaturated {RoW}| production | Alloc Rec, U	Ecoinvent	2016
Recycled glass	Glass cullet, sorted {RoW}| treatment of waste glass from unsorted public collection, sorting | Alloc Rec, U	Ecoinvent	2016
Titanium dioxide	Titanium dioxide {RER}| production, chloride process | Alloc Rec, U	Ecoinvent	2016
Additive (TBPB)	Chemical, organic {GLO}| production | Alloc Rec, U	Ecoinvent	2016
Additives (unspecified)	Chemical, organic {GLO}| production | Alloc Rec, U	Ecoinvent	2016
Radianz Packaging			
Protection Film	Packaging film, low density polyethylene {RoW}| production | Alloc Rec, U	Ecoinvent	2016
Wooden Pallet	Re-used wood pallet	SCS	2017
Ancillary Materials for Manufacturing Radianz			
Covering Paper	Kraft paper, unbleached {RoW}| production | Alloc Rec, U	Ecoinvent	2016
Acetone	Acetone, liquid {RoW}| production | Alloc Rec, U	Ecoinvent	2016
Electricity/Heat/Resources for Manufacturing			
Electricity	Electricity, medium voltage {KR}| market for | Alloc Rec, U	Ecoinvent	2016
Natural Gas	Heat, district or industrial, natural gas {GLO}| market group for | Alloc Rec, U	Ecoinvent	2016
Steam	Steam, in chemical industry {KR}| production | Alloc Rec, U	Ecoinvent; SCS	2016; 2017
Water	Tap water {RoW}| market for | Alloc Rec, U	Ecoinvent	2010
Fabrication of Radianz			
Adhesive	Methyl methacrylate {GLO}| market for | Alloc Rec, U; Chemical, organic {GLO}| market for | Alloc Rec, U	Ecoinvent	2016
Electricity	Electricity, medium voltage {US}| market group for | Alloc Rec, U	Ecoinvent	2016
Use of Radianz			
Stone Cleaner	Chemical, organic {GLO}| market for | Alloc Rec, U; Ethanol, without water, in 99.7% solution state, from ethylene {GLO}| market for | Alloc Rec, U; Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Alloc Rec, U; Water, deionised, from tap water, at user {RoW}| market for water, deionised, from tap water, at user | Alloc Rec, U	Ecoinvent	2016
Soap	Soap {GLO}| market for | Alloc Rec, U	Ecoinvent	2016
Water	Tap water {RoW}| market for | Alloc Rec, U	Ecoinvent	2016
Transportation			
Rail	Transport, freight train {CN}| market for | Alloc Rec, U	Ecoinvent	2016
Road	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Alloc Rec, U	Ecoinvent	2016
Ship	Transport, freight, sea, transoceanic ship {GLO}| market for | Alloc Rec, U	Ecoinvent	2016

Data Quality

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage: Age of data and the minimum length of time over which data is collected	Manufacturer data (primary data) are based on 2016 annual production, respectively. Representative datasets (secondary data) used for upstream and background processes are generally less than 10 years old. All of the data used represented an average of at least one year's worth of data collection.
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Representative data used in the assessment are representative of US, Korean, Global, or "Rest-of-World" (average for all countries in the world with uncertainty adjusted). Datasets chosen are considered sufficiently similar to actual processes.
Technology Coverage: Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations.
Precision: Measure of the variability of the data values for each data expressed	Precision of results are not quantified due to a lack of data. Data collected for operations were typically averaged for one year and over multiple operations, which is expected to reduce the variability of results.
Completeness: Percentage of flow that is measured or estimated	Except where noted, the LCA model included all known mass and energy flows. In some instances, surrogate data used to represent upstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 10% of the total environmental impact for each indicator are excluded. In total, these missing data represent less than 5% of the mass or energy flows.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	Data used in the assessment represent typical or average processes as currently reported from multiple data sources, and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction. Some proxy datasets are used to represent materials due to the lack of data available.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent data where available. Different portions of the product life cycle are equally considered.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, this assessment would be reproducible by other practitioners. All assumptions, models, and data sources are documented.
Sources of the Data: Description of all primary and secondary data sources	For manufacturing and packaging, primary data were provided by Lotte. Similarly, the upstream transport of materials is based on primary data provided by Lotte. The fabrication process was derived from fabrication manuals provided by Lotte to derive key parameters for calculations. For the distribution of product from manufacturing facility to distribution center, a weighted average based on primary data was provided by Lotte. Where primary upstream data were unavailable, secondary data were used. The principal source of secondary LCI data is Ecoinvent.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	Uncertainty related to the product materials and packaging is low. Data for upstream operations relied upon use of existing representative datasets. These datasets contained relatively recent data (<10 years), but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact methods required by the PCR include impact potentials, which lack characterization of providing and receiving environments or tipping points.

Allocation

Resource use at the Yeosu-si, Jeollanam-do, South Korea facility (e.g., water and energy) was allocated to the product based on the product weight as a fraction of the total facility production.

The countertop product system includes recycled materials, which are allocated using the recycled content allocation method (also known as the 100-0 cut off method). Using the recycled content allocation approach, system inputs with recycled content do not receive any burden from the previous life cycle other than reprocessing of the waste material. At end of life, materials which are recycled leave the system boundaries with no additional burden.

Impacts from transportation were allocated based on the mass of material and distance transported.

System boundaries

The system boundaries of the life cycle assessment for the countertop was cradle-to-grave. A description of the system boundaries for this EPD are as follows:

- Material acquisition and pre-processing stage – This stage includes extraction of virgin materials and reclamation of non-virgin feedstock. Resource use, emissions, and generated wastes associated with extraction and processing of the raw materials are included. All upstream transportation, including transportation to the manufacturing facility, is included.
- Construction stage – This stage includes all the relevant manufacturing and fabrication processes. Resource use, emissions, and generated wastes associated with these processes are included. Transport of semi-finished products between facilities and materials used in packaging of the product are included. Production of capital goods, infrastructure, production of manufacturing equipment, and personnel related activities are excluded.
- Installation stage – This stage includes the delivery of the countertop to the point of installation, and energy and ancillary materials used during installation. Waste generated during countertop installation is included. Sinks, plumbing fixtures, and cook tops are excluded.
- Use stage – The use stage includes the cleaning of the countertop during its lifetime, as well as extraction, manufacturing and transport of all sundry material for cleaning. In accordance with the PCR, maintenance and repair of the countertop is generally insignificant and is excluded from this stage. The reference service life for the countertop in this EPD is 10 years.
- End of life stage – The end of life stage includes the transport of the countertop and its original packaging to end of life processes including landfill, incineration, and recycling.

Cut-off criteria

According to the PCR, mass and energy flows that consist of less than 1% may be omitted from the inventory analysis. Cumulative omitted mass or energy flows shall not exceed 5%. In the present study, except as noted, all known materials and processes were included in the life cycle inventory.

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