ENVIRONMENTAL PRODUCT DECLARATION

HIGHLANDER COOL SHINGLES

HIGHLANDER COOL SHINGLES
SOUTHGATE, CA FACILITY

Designed in the popular architectural style, and made with our industry-leading NEX® Rubberized Asphalt, Highlander Cool shingles deliver great all-weather resilience, a Class 2 hail impact rating, and include granules that help cool the roof and clean the air of emission pollutants.

Malarkey Roofing Products®

Malarkey Roofing Products® offers a family of shingle products designed with a goal of sustainability in focus through each step of the product's life cycle. From a shingle's manufacture to the end of its service life, Malarkey shingles are created for superior performance, reliability, and limited impact on the environment.

Malarkey worked with the Asphalt Roofing Manufacturers Association (ARMA) to complete Environmental Product Declarations (EPD) focused on low slope roof systems.

In the roofing business since 1956, Malarkey Roofing Products® is a company perpetuated by the success and foresight of previous and current generations. With a keen ability to innovate, the company has advanced modern roofing materials by engineering solutions to common roof problems. Today, Malarkey is dedicated to keeping its roofing materials out of the waste stream and preserving the quality of life on our planet.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

ENVIRONMENTAL PRODUCT DECLARATION

Malarkey Roofing Products®

Highlander Cool Shingles
Southgate, CA Facility

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

According to ISO 14025 and ISO 21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Solutions www.ul.com 333 Pfingsten Rd, Northbrook IL, 60062 www.spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	Program Operator Rules v 2.7 2022
MANUFACTURER NAME AND ADDRESS	Malarkey Roofing Products, P.O. Box 17217, Portland, OR 97217
DECLARATION NUMBER	4791004914.101.2 (Updated 4/26)
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	100 square meters of installed Highlander Cool shingles (Southgate, CA Facility)
REFERENCE PCR AND VERSION NUMBER	Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (December 2018, version 3.2) PCR Guidance for Building-Related Products and Services - Part B: Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing EPD Requirements, v1.2, 24/05/2021
CSI MASTERFORMAT	07 31 13
DESCRIPTION OF PRODUCT APPLICATION/USE	Steep-slope weatherproofing of roofs
PRODUCT RSL DESCRIPTION (IF APPL.)	HIGHLANDER COOL Shingles (Southgate, CA Facility): 25 years HIGHLANDER COOL Premium Shingles (Southgate, CA Facility): 35 years
MARKETS OF APPLICABILITY	Residential and Commercial Markets
DATE OF ISSUE	April 1, 2024
PERIOD OF VALIDITY	5 Years
EPD TYPE	Plant-Specific, Product-Specific
RANGE OF DATASET VARIABILITY	n/a
EPD SCOPE	Cradle to grave
YEAR(S) OF REPORTED PRIMARY DATA	2019
LCA SOFTWARE & VERSION NUMBER	GaBi v10.6
LCI DATABASE(S) & VERSION NUMBER	GaBi Database Schema v8007 Content Database v2021.2
LCIA METHODOLOGY & VERSION NUMBER	TRACI 2.1; CML 4.2

The PCR review was conducted by:	UL Solutions PCR Review Panel epd@ul.com
This declaration was independently verified in accordance with ISO 14025: 2006. The UL Environment "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report," v3.2 (December 2018), in conformance with ISO 21930:2017, serves as the core PCR. ☐ INTERNAL ☐ EXTERNAL	Cooper McCollum Cooper McCollum, UL Solutions
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Sustainable Solutions Corporation
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Lindita Bushi Lindita Bushi, PhD, Athena Sustainable Materials Institute

LIMITATIONS

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; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance of shingles using EPD information shall be based on the product's use and impacts at the construction works level, and therefore EPDs may not be used for comparability purposes when not considering the construction works energy use phase as instructed under this PCR. Full conformance with the PCR for shingles allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category Part B PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

1. Product Definition and Information

1.1. Description of Company/Organization

In the roofing business since 1956, Malarkey Roofing Products® is a company perpetuated by the success and foresight of previous and current generations. With a keen ability to innovate, the company has advanced modern roofing materials by engineering solutions to common roof problems. Today, Malarkey is dedicated to keeping its roofing materials out of the waste stream and preserving the quality of life on our planet.

Malarkey manufactures asphalt shingles in three different facilities including: Portland, OR; Southgate, CA; and Oklahoma City, OK. All three of Malarkey's asphalt roofing facilities have achieved the Waste Diversion from Landfill certification from GreenCircle Certified, LLC, demonstrating responsible management of end-of-life materials. GreenCircle provides third-party certification of sustainability claims through a rigorous scientific evaluation based on internationally recognized standards and guidelines.

1.2. Product Description

Figure 1 - Highlander Cool Shingles

Highlander Cool Shingle Line

Highlander Cool is a solar reflective, laminated architectural shingle fortified with sustainable NEX polymer modified asphalt technology for enhanced granule adhesion and increased weather protection. Highlander Cool shingles have measured radiative property values listed with the Cool Roof Rating Council and can be used to comply with California Energy Code Title 24, Part 6 Cool Roof Requirements.

Product Identification:282

Product Specification: ASTM D3018 Type I, ASTM D3462, CSA A123.5

Manufacturing Location: Southgate, CA

1.3. Application

Steep-slope roofing systems are installed on roofs with slope equal to or greater than 2:12. Steep-slope roofing systems are primarily used to protect residential and light commercial construction from the weather. Asphalt shingle roofing systems provide protection against wind, rain, snow, and extreme temperatures. Additionally, Highlander Cool Premium offers solar reflectance to aid in the cooling of residential and commercial buildings.

1.4. Material Composition

The raw material composition of the Highlander Cool product line can be found in the table below. The amounts of each of the raw material inputs listed correspond to the declared unit amount. These are production-weighted amounts, which have been averaged across the three facilities modeled in this LCA.

Table 1 – Raw Material Composition of Highlander Cool product line (100 m²)

PRODUCT	HIGHLANDER COOL SHINGLES
Asphalt	10%-20%
Recycled Rubber	0.5%-5%
Styrene Butadiene Styrene	0.5%-5%
Fiberglass Mat	0.5%-5%
Granules	30%-40%
Limestone	30%-40%
Sand	5%-10%
Others	0.5%-5%

1.5. Technical Requirements

The appropriate ASTM and CSA product specifications are provided below for each of the products modeled in this LCA.

Table 2 - Technical Data

PRODUCT	SPECIFICATIONS
Highlander Cool Shingles	Highlander Cool meets the requirements of UL 2218 Class 4 Impact Resistance, ASTM D 3018 Type 1, ASTM D3161 Class F, ASTM E 108 Class 'A', Meets CSA A 123.5, and Texas Department of Insurance Class 4 impact resistance. It is listed with ITS/Warnock-Hersey and carries ICC Approval - ESR 3150

1.6. Properties of Declared Product as Delivered

The product(s) declared in this document comply the standards listed in Table 2. For more information, the final evaluation report/certification/registration is available at: malarkeyroofing.com

2. Methodological Framework

2.1. Functional Unit

The functional unit for this study is 100 square meters of constructed (i.e. installed) shingles. No underlayment or other roofing system products are included within this scope. A reference service life of 25 years is assumed for the shingles; the life of the building is assumed to be 75 years. Fasteners are included in the installation stage of this study.

Table 3 - Functional Unit Properties

NAME	HIGHLANDER COOL	UNIT
Functional Unit	100	m²
Mass	1,016	kg

Thickness to achieve Functional Unit	5	mm

2.2. System Boundary

This EPD covers the full cradle-to-grave life-cycle stages of the Highlander Cool product line. This EPD encompasses raw material extraction and processing, product manufacturing and installation, use, and material disposal. Transportation between stages is accounted for, including raw material transportation to the manufacturing facility, finished product transportation to the construction site, and transport of the roof system at the end-of-life to the landfill. Use, maintenance, repair, replacement, and refurbishment are also included in this evaluation. In addition, production, manufacture and construction of manufacturing equipment and infrastructure, repair and maintenance of the production system, energy and water use related to company management and sales, delivery vehicles and laboratory equipment, and maintenance and operation of support equipment are all outside of the scope of this study. As an adaptation of the PCR, Table 4 below indicates the particular life-cycle stages and individual modules included within the system boundaries of the underlying LCA study. For each of the life-cycle stages, the individual modules that have been included are indicated with an X.

Table 4 – Life-cycle Stages and Modules Included in the System Boundaries

Product Stage			Construction Stage		Use Stage					End-of-Life Stage			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4
Raw materials supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction	Transport	Waste processing	Disposal
X	X	X	X	X	X	X	X	X	X	X	X	X	X

Capital goods and infrastructure flows have been excluded from the unit processes used to model the LCIA, as these goods do not significantly impact the LCA.

2.3. Production Specific Calculations of Use Phase (Modules B1-B7)

Minimal maintenance is required during the product's service life. The product typically lasts 25 years, at which time replacement of the shingle is required.

These products utilize 3M Smog-Reducing Granules that harness sunlight to photocatalytically convert smog (NO, NO_2) into water-soluble ions (NO_3), actively reducing air pollution. An analysis was conducted showing the benefits of these granules that are integrated into the product line under life cycle stage B1. The B2, B3, B5, B6, and B7 life cycle stages are assumed to be null.

2.4. Reference Service Life and Estimated Building Service Life

The estimated service life of the Highlander Cool shingles product line is 25 years and for Highlander Cool Premium shingles product line is 35 years. The service life of a product may depend on the environmental conditions where the product is being used, and in particular the service temperature. The building service life is assumed to be 75 years; therefore, 2.0 product replacements are included.

2.5. Allocation

Manufacturing values were obtained from the Southgate, CA facility.

Whenever allocation was necessary, the method chosen was based upon the nature and purpose of the process. Allocation calculations that were made are consistent with the data quality and availability as well as the allocation method used. The physical relationship between flows (mass) was used to conduct allocation whenever applicable.

This LCA follows an attributional approach as outlined in ISO 21930 Section 7.1.1 with no impact assigned to pre- and post-consumer recycled materials entering or leaving the system.

2.6. Cut-off Rules

The cut-off criteria used in the underlying LCA, the results of which are declared in this EPD, follow the guidelines set forth in the PCR and have been reproduced as follows:

- *Mass: If a flow is less than 1% of the cumulative mass of the model flows, it may be excluded, provided its environmental relevance is minor.*
- *Energy: If a flow is less than 1% of the cumulative energy of the system model, it may be excluded, provided its environmental relevance is minor.*
- *Environmental relevance: Material and energy flows known to have the potential to cause significant emissions into air, water, or soil related to the environmental indicators of these PCR shall be included even if such flows meet the above criteria for Mass and Energy.*
- *At least 95% of the energy usage and mass flow shall be included and the life-cycle impact data shall contain at least 95% of all elementary flows that contribute to each of the declared category indicators.*
- *A list of hazardous and toxic materials and substances shall be included in the inventory and the cutoff rules do not apply to such substances.*

Following the cut-off criteria listed above, the energy required to install the fasteners onto the roofing shingle has been excluded as the overall electrical consumption of a nail gun is much less than the energy required to produce the materials. All reported data were incorporated and modeled using best available LCI data.

2.7. Data Sources

The following data sources were used to develop the LCIA from the inventory data collected.

Table 5 – Data Sources

PRODUCT	DATABASE
Asphalt	GaBi v2021.2
Recycled Rubber	GaBi v2021.2 and Cut-Off Methodology
Styrene Butadiene Styrene	GaBi v2021.2
Fiberglass Mat	GaBi v2021.2
Granules	GaBi v2021.2
Limestone	GaBi v2021.2
Sand	GaBi v2021.2
Others	GaBi v2021.2
Electricity	GaBi v2021.2
Natural Gas	GaBi v2021.2

Waste	GaBi v2021.2

2.8. Data Quality

As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, no better precision is reachable within this product. Seasonal variations and variations across different manufacturers were balanced out by using yearly averages and weighted averages. All primary data were collected with the same level of detail, while all background data were sourced from GaBi 2021 databases. Allocation and other methodological choices were made consistently throughout the model.

2.9. Period Under Review

The period under review spans from October 2018 to September 2019.

2.10. Comparability and Benchmarking

Environmental declarations from different programs (ISO 14025) may not be comparable. Comparison of the environmental performance of shingles using EPD information shall be based on the product's use and impacts at the construction works level, and therefore EPDs may not be used for comparability purposes when not considering the construction works energy use phase as instructed under this PCR. Given this PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability explained. Full conformance with the PCR for shingles allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category Part B PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared. EPDs shall not contain statements of the superiority of one product over a competitive product that performs the same functions.

2.11. Estimates and Assumptions

For recycled content, the cut-off recycling methodology was utilized. Installation scrap rates of 5% were assumed, although this can vary at each job site. The lifetime was determined by detailed surveys of installed shingles.

3. Technical Information and Scenarios

3.1. Manufacturing

Figure 3 below shows the manufacturing process for asphalt shingles at the Southgate, CA facility. Materials such as asphalt, sand, limestone, polymers, and fiberglass mats are transported to the production facility where the raw materials are staged. Then, asphalt and polymers are mixed and undergo limestone heating. The fiberglass mats are put into place so that the asphalt mixture can be applied to each mat followed by an application of sand and granule. The sheets are then pressed and cooled with water. The paint line and wind sealant are then applied to the cooled shingles along with release soap. The shingles then get patterns cut into their webs followed by an application of laminate adhesive. The webs then have to be realigned and pressed before the shingles can be cut. The shingle bundles are then stacked and packed for distribution.

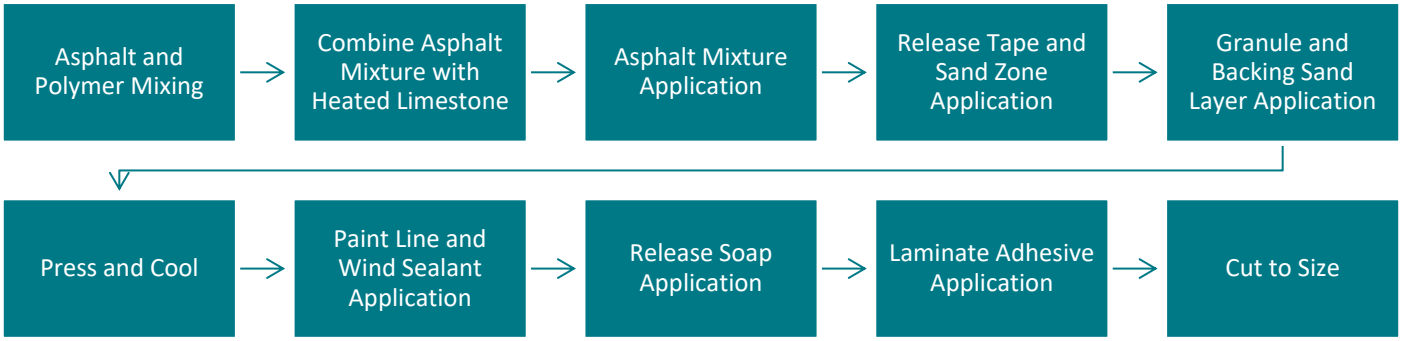

Figure 2 - Process Flow Diagram of Asphalt Shingles

3.2. Packaging

The packaging materials include wood pallets and polyethylene wrap. Upon arrival at the construction site, packaging materials are discarded. These materials were assumed to be landfilled.

3.3. Transportation

The following table details the transportation of the product to the building site.

Table 6 - Transport to the building site (A4)

NAME	HIGHLANDER COOL	UNIT
Fuel type	Diesel	-
Liters of fuel	36.2	l/100km
Vehicle type	Tractor Trailer, Rail, Ocean Freighter	-
Transport distance (truck)	692	km
Transport distance (rail)	-	km
Transport distance (ship)	-	Km
Capacity utilization (including empty runs, mass based	90%	%
Gross density of products transported	>2000	kg/m^3
Capacity utilization volume factor	1	-

3.4. Product Installation

Shingles are installed with nails starting from the eave edge to the ridge of the roof. For this EPD, the only product being observed are the asphalt shingles. A 5% scrap rate is assumed during the installation of asphalt shingles. Additionally, packaging waste is generated and assumed to be landfilled.

Table 7 – Installation

NAME	HIGHLANDER COOL	UNIT
Ancillary materials	1.84E-01	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	-	m^3
Other resources	-	kg
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Product loss per functional unit	5.08E+01	kg
Waste materials at the construction site before waste processing, generated by product installation	5.10E+01	kg
Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)	Construction & Demolition Waste: 5.1E+01 Packaging: 1.84E-01	kg
Biogenic carbon contained in packaging	9.15E-02	kg CO_2
Direct emissions to ambient air, soil and water	-	kg
VOC content	n/a	µg/m^3

3.5. Use

The following table provides information regarding the reference service life of the product lines. These products utilize

3M Smog-Reducing Granules that harness sunlight to photocatalytically convert smog (NO, NO_2) into water-soluble ions (NO_3), actively reducing air pollution. An analysis was conducted showing the benefits of these granules that are integrated into the product line under life cycle stage B1. B2, B3, B5, B6, and B7 are assumed to be null.

Table 8 - Reference Service Life

Name	HIGHLANDER COOL	Unit
RSL	25	years
Declared product properties and finishes, etc.	Please refer to the installation guides below: https://malarkeyroofing.com/resources/installation-guides	
Design application		
An assumed quality of work, when installed in accordance with the manufacturer's instructions		
Outdoor environment	Please visit https://malarkeyroofing.com/ for more information.	
Indoor environment	n/a	
Use conditions	Please visit https://malarkeyroofing.com/ for more information.	
Maintenance	n/a	

Table 9 - Replacement (B4)

NAME	HIGHLANDER COOL	UNIT
Reference service life	25	years
Replacement cycle	2.0	Number/ ESL - 1
Energy input, specified by activity, type and amount	-	kWh
Net freshwater consumption specified by water source and fate	-	m^3
Replacement of worn parts, specify parts/materials	Asphalt shingle: 1.02E+03 per replacement	kg
Direct emissions to ambient air, soil and water	n/a	kg

3.6. Disposal

Upon the end of the product service life, the products are removed from the building roof. Some products may be recycled at end of life, but primary data is not available to quantify the percentage, so in this study we assume the product is sent to a landfill. C1 and C3 are assumed to be null.

Table 10 - End of Life

NAME		HIGHLANDER COOL	UNIT
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)		Products are manually removed from the roof and typically combined with construction and demolition waste.	
Collection process (specified by type)	Collected separately	-	kg
	Collected with mixed construction waste	1,016	kg
Recovery (specified by type)	Reuse	-	kg
	Recycling	-	kg
	Landfill	1,016	kg
	Incineration	-	kg
	Incineration with energy recovery	-	kg
	Energy conversion efficiency rate	-	
Disposal (specified by type)	Product or material for final deposition	Asphalt shingle:1,016	kg
Removals of biogenic carbon (excluding packaging)		-	kg CO_2

3.7. Re-use Phase

While the re-use of shingles is not assumed, recycling of shingles is feasible. Shingles can be recycled, and often are used in asphalt mixes depending upon various states' requirements. Shingles also may provide energy benefit in waste-in-energy incineration facilities.

4. Highlander Cool Environmental Indicators Results

4.1. Life Cycle Impact Assessment Results

Results are reported based on characterization factors from the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI 2.1 impact categories). These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined, and LCA should continue making advances in their development. However, the EPD users shall not use additional measures for comparative purposes. Additionally, impact categories taken from the University of Leiden (CML) methodology are reported to facilitate the use of this EPD outside of North America.

LCA results are presented per the functional unit (100 m^2 of asphalt shingles). Note that, at this point, the reported impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. Life Cycle Impact Assessment (LCIA) results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

Table 1 – Highlander Cool Southgate, CA Facility North American Impact Assessment Results

TRACI v2.1 Impact Assessment	Acronym	Unit	A1-A3	A4	A5	B1	B4	C2	C4
Global Warming Potential	GWP 100	kg CO_2 eq	2.49E+02	6.52E+01	2.08E+01	0.00E+00	1.12E+03	7.57E+00	2.19E+02
Ozone Depletion Potential	ODP	kg CFC-11 eq	5.39E-07	2.47E-09	2.71E-08	0.00E+00	1.14E-06	2.86E-10	6.79E-13
Acidification Potential	AP	kg SO_2 eq	1.02E+00	3.92E-01	1.04E-01	-2.83E-02	6.00E+00	4.54E-02	1.44E+00
Eutrophication Potential	EP	kg N eq	7.79E-02	2.17E-02	1.70E-02	7.78E-03	1.27E+00	2.52E-03	5.14E-01
Photooxidant Chemical Potential	POCP	kg O_3 eq	1.66E+01	1.08E+01	1.46E+00	-1.00E+00	6.77E+01	1.25E+00	3.72E+00
Fossil Fuel Depletion	FFD	MJ surplus	6.85E+02	1.15E+02	4.07E+01	0.00E+00	1.76E+03	1.34E+01	2.78E+01

**Life Cycle Stages not shown have no potential environmental impact, i.e. an impact value of 0.*

Table 2 - Highlander Cool Southgate, CA Facility EU Impact Assessment Results

CML v4.2 Impact Assessment	Acronym	Unit	A1-A3	A4	A5	B1	B4	C2	C4
Global Warming Potential	GWP 100	kg CO2 eq	1.86E+02	6.54E+01	1.82E+01	0.00E+00	1.04E+03	7.59E+00	2.42E+02
Ozone Depletion Potential	ODP	kg CFC-11 eq	3.34E-09	2.46E-09	2.91E-10	0.00E+00	1.28E-08	2.86E-10	3.80E-11
Acidification Potential	AP	kg SO2 eq	4.87E-01	3.22E-01	5.43E-02	-2.02E-02	2.97E+00	3.73E-02	5.85E-01
Eutrophication Potential	EP	kg PO4-3 eq	8.53E-02	5.73E-02	2.40E-02	-1.21E-03	1.79E+00	6.65E-03	7.21E-01
Photooxidant Chemical Potential	POCP	kg ethene eq	6.74E-02	3.76E-02	8.97E-03	-1.13E-03	5.55E-01	4.36E-03	1.59E-01
Abiotic Depletion Potential (elements)	ADPE	kg Sb-eq	1.19E-03	2.71E-08	5.96E-05	0.00E+00	2.51E-03	3.14E-09	4.14E-06
Abiotic Depletion Potential (fossil fuels)	ADPF	MJ, LHV	4.19E+03	8.31E+02	2.56E+02	0.00E+00	1.12E+04	9.65E+01	2.14E+02

**Life Cycle Stages not shown have no potential environmental impact, i.e. an impact value of 0.*

4.2. Life Cycle Inventory Results

The following table details the resources used in the life cycle of the Highlander Cool asphalt shingle product line.

Table 3 - Highlander Cool Southgate, CA Facility Resource Use

Resource	Acronym	Unit	A1-A3	A4	A5	B1	B4	C2	C4
Renewable Primary Energy for Energy Sources	RPR_E	MJ, LHV	5.85E+02	0.00E+00	2.99E+01	0.00E+00	1.28E+03	0.00E+00	2.59E+01
Renewable Primary Energy for Materials	RPR_M	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Renewable Primary Energy Total	RPR_T	MJ, LHV	5.85E+02	0.00E+00	2.99E+01	0.00E+00	1.28E+03	0.00E+00	2.59E+01
Non-Renewable Primary Energy for Energy Sources	$NRPR_E$	MJ, LHV	4.33E+03	8.39E+02	2.64E+02	0.00E+00	1.15E+04	9.74E+01	2.21E+02
Non-Renewable Primary Energy for Materials	$NRPR_M$	MJ, LHV	7.64E+02	0.00E+00	0.00E+00	0.00E+00	1.53E+03	0.00E+00	0.00E+00
Non-Renewable Primary Energy Total	$NRPR_T$	MJ, LHV	5.09E+03	8.39E+02	2.64E+02	0.00E+00	1.30E+04	9.74E+01	2.21E+02
Secondary Materials	SM	kg	9.44E+00	0.00E+00	0.00E+00	0.00E+00	1.89E+01	0.00E+00	0.00E+00
Renewable Secondary Fuels	RSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-Renewable Secondary Fuels	NRSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported Renewable Energy	RE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Freshwater Consumption	FW	m^3	1.29E+00	0.00E+00	0.00E+00	0.00E+00	2.58E+00	0.00E+00	0.00E+00

**Life Cycle Stages not shown have no potential environmental impact, i.e. an impact value of 0.*

The following table details the wastes and output flows used in the life cycle of the Highlander Cool asphalt shingle product line.

Table 4 - Highlander Cool Southgate, CA Facility Output Flows and Waste Categories

Waste Parameters	Parameter	Unit	A1-A3	A4	A5	B1	B4	C2	C4
Hazardous Waste	HWD	kg	2.34E-04	0.00E+00	1.17E-05	0.00E+00	4.91E-04	0.00E+00	5.51E-09
Non-Hazardous Waste	NHWD	kg	1.18E+01	0.00E+00	1.47E+01	0.00E+00	1.20E+03	0.00E+00	5.73E+02
High-Level Radioactive Waste	HLRW	kg	4.57E-02	0.00E+00	2.34E-03	0.00E+00	1.01E-01	0.00E+00	2.45E-03
Intermediate/Low-Level Radioactive Waste	ILLRW	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Components for Reuse	CRU	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for Recycling	MR	kg	1.17E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for Energy Recovery	MER	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Exported Energy	EE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Life Cycle Stages not shown have no potential environmental impact, i.e. an impact value of 0.*

The following table details the carbon emissions and removals used in the life cycle of the Highlander Cool asphalt shingle product line.

Table 5 - Highlander Cool Southgate, CA Facility Carbon Emissions and Removals

CARBON EMISSION/ REMOVAL	ACRONYM	UNIT	A1-A3	A4	A5	B1	B4	C2	C4
Removals associated with biogenic carbon content of the bio-based product	BCRP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emissions associated with biogenic carbon content of the bio-based product	BCEP	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Removals associated with biogenic carbon content of the bio-based packaging	BCRK	kg CO_2	3.36E-01	0.00E+00	0.00E+00	0.00E+00	6.71E-01	0.00E+00	0.00E+00
Emissions associated with biogenic carbon content of the bio-based packaging	BCEK	kg CO_2	0.00E+00	0.00E+00	3.36E-01	0.00E+00	6.71E-01	0.00E+00	0.00E+00
Carbon emissions from calcination	CCE	kg CO_2	2.02E+00	0.00E+00	0.00E+00	0.00E+00	4.05E+00	0.00E+00	0.00E+00
Carbon removals from carbonation	CCR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emissions from combustion of waste from renewable sources used in production processes	BCEW	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emissions from combustion of waste from non-renewable sources used in production processes.	CWNR	kg CO_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

**Life Cycle Stages not shown have no potential environmental impact, i.e. an impact value of 0.*

5. Additional Environmental Information

5.1. Environment and Health During Manufacture

Malarkey's Southgate, CA facility has achieved the Waste Diversion from Landfill certification from GreenCircle, demonstrating responsible management of end-of-life materials. GreenCircle provides third-party certification of sustainability claims through a rigorous scientific evaluation based on internationally recognized standards and guidelines.

5.2. Environment and Health During Installation

There are no relevant environmental or health effects relevant during installation.

5.3. Environment and Health During Use

Highlander Cool contains 3M Smog-Reducing Granules; these granules harness sunlight to photocatalytically convert smog (NO, NO_2) into water-soluble ions (NO_3), actively reducing air pollution.

5.4. Extraordinary Effects

Fire

Highlander Cool meets the requirements of ASTM E 108 Class 'A' for fire resistance.

Water

There are no relevant water extraordinary effects relevant for Highlander Cool.

Mechanical Destruction

Highlander Cool meets the requirements of UL 2218 Class 2 Impact Resistance, ASTM D3161 Class F for Standard Testing Procedures for Wind Resistance, and Texas Department of Insurance Class 2 impact resistance. Highlander Cool Premium meets the requirements of UL 2218 Class 4 Impact Resistance, ASTM D3161 Class F for Standard Testing Procedures for Wind Resistance, and Texas Department of Insurance Class 4 impact resistance.

5.5. Environmental Activities and Certifications

Malarkey's Southgate, CA facility has achieved GreenCircle Certification for Waste Diversion from Landfill certification, demonstrating responsible management of end-of-life materials.

6. LCA Interpretation

Based on the results listed above, the life cycle environmental impacts are strongly driven by the replacements required for a 75-year life building. Outside of replacements, raw materials and installation scrap are significant drivers of the overall environmental impacts. For raw materials, the mat, granules and SBS are the largest contributors to the environmental impacts.

7. References

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8. Contact Information

8.1. Study Commissioner

Malarkey Roofing Products
P.O. Box 17217
Portland, OR 97217
Toll: (800) 545-1191
Tel: (503) 283-1191
Fax: (503) 289-7644
www.malarkeyroofing.com
https://malarkeyroofing.com/contact-us

8.2. LCA Practitioner

Sustainable Solutions Corporation
155 Railroad Plaza, Suite 203
Royersford, PA 19468 USA
(610) 569-1047
info@sustainablesolutionscorporation.com
www.sustainablesolutionscorporation.com