Timberline® HDZ™ Shingles

Environmental Product Declaration

Program Operator	NSF Certification, LLC 789 N. Dixboro Ann Arbor, MI 48105 www.nsf.org
General Program instructions and Version Number	NSF Program Operator Rules, NSF International. February 23, 2015.
Manufacturer Name and Headquarter Address	GAF 1 Campus Dr, Parsippany NJ 07054
Declaration Number	EPD10397
Declared Product and Declared Unit	Timberline® HDZ™ 1 square meter corresponding to the amount of asphalt shingles being manufactured during calendar year 2018 for one square meter of constructed area
Facilities Included	Baltimore, MD; Dallas, TX; Fontana, CA; Michigan City, IN Minneapolis, MN; Shafter, CA; Tampa, FL; Tuscaloosa, AL Myerstown, PA; Ennis, TX
Reference PCR and Version Number	UL PCR Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2 UL PCR Part B: Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing EPD Requirements (UL 10010-11)
Product's intended Application and Use	Roofing
Product RSL	N/A
Markets of Applicability	North America
Date of Issue	7/29/2020
Period of Validity	5 years from date of issue
EPD Type	Product Specific
Range of Dataset Variability	N/A
EPD Scope	Cradle to Gate with Options
Year of reported manufacturer primary data	2018
LCA Software and Version Number	GaBi 9.2.0.58
LCI Database and Version Number	GaBi Database, Service Pack 40
LCIA Methodology and Version Number	TRACI 2.1 CML 2001-Jan 2016
The sub-category PCR review was conducted by:	Review Panel chaired by Dr. Thomas Gloria
This declaration was independently verified in accordance with ISO 14025: 2006. The UL Environment "Part A: Life Cycle Assessment Calculation Rules and Report Requirements" v3.2 (December 2018), based on CEN Norm EN 15804 (2012) and ISO 21930:2017, serves as the core PCR, with additional considerations from the USGBC/UL Environment Part A Enhancement (2017) ☐ Internal ☒ External	Jenny Oorbeck joorbeck@nsf.org
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	WAP Sustainability Consulting, LLC
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Jack Geibig - EcoForm jgeibig@ecoform.com

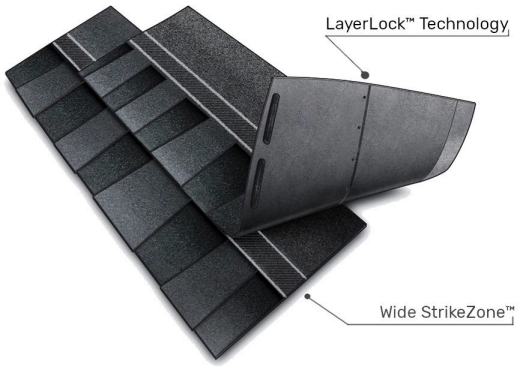
Limitations:
Environmental declarations from different programs (ISO 14025) may not be comparable.
Comparison of the environmental performance of Asphalt Shingles using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase as instructed under this PCR.
Full conformance with the PCR for Asphalt Shingles allows EPD comparability only when all stages of a life cycle have been considered. 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.

Company Description

Founded in 1886, GAF is the leading roofing manufacturer in North America. As a member of the Standard Industries family of companies, GAF is part of the largest roofing and waterproofing business in the world. The company's products include a comprehensive portfolio of roofing and waterproofing solutions for residential and commercial properties as well as for civil engineering applications. The full GAF portfolio of solutions is supported by an extensive national network of factory-certified contractors. GAF continues to be the leader in quality and offers comprehensive warranty protection on its products and systems. The company's success is driven by a commitment to empowering its people to deliver advanced quality and purposeful innovation. For more information about GAF, visit www.gaf.com.

Product Description

GAF Timberline® HDZ™ is an asphalt shingle reinforced with a fiberglass mat. It is equipped with GAF's proprietary technologies including LayerLock™ and Dura Grip™ sealant which provide durable and strong bond between overlapping shingle layers, and exceptional wind uplift performance. The CSI division number for this product is 07 31 13 (Asphalt Shingles).



Application

GAF Timberline® HDZ™ is used for residential roofing applications.

Technical Data

Table 1: Technical Data

Test Method	HDZ™
ASTM D3018	Type 1
ASTM D3462	Compliant
CSA A123.5	Yes

Properties of the Declared Products as Delivered

Shingles are delivered as bundles with options of 20 and 22 shingles per bundle. The technical details of the product are provided in Table 1 above.

Declaration of Methodological Framework

The type of EPD is cradle to gate with options. LCA modules that are included and are summarized in Table 8. No known flows are deliberately excluded from this EPD.

Material Composition

Table 2: Composition

Material	HDZ™
Limestone	30-40%
Natural mineral granules	30-40%
Bitumen	15-20%
Silica	5-10%
Fiberglass	1-5%
Pigment	1-2%
Ceramic	1-2%
Urea formaldehyde resin	0-1%
SBS Rubber	0-1%

A range has been presented for composition of product to maintain confidentiality. No substances required to be reported as hazardous are associated with the production of this product.

Manufacturing

This stage includes an aggregation of raw material extraction, supplier processing, delivery, manufacturing and packaging by GAF.

GAF receives raw materials from their suppliers in the US. The raw materials include fiberglass mat, bitumen, ceramic-coated mineral granules, silica and limestone. The fiberglass mat will go through a sequence of processes to become asphalt shingles, including dry looping (filler is added to fiberglass mat), saturation (mat soaking in the bitumen), coating (applying asphalt coating), mineral surfacing, cutting and packaging. HDZ is manufactured in 10 facilities across the US to serve different regions of the country. The facilities are respectively located in Baltimore MD, Dallas TX, Fontana, CA, Michigan City IN, Minneapolis MN, Shafter CA, Tampa FL, Tuscaloosa AL, Myerstown PA, and Ennis TX.

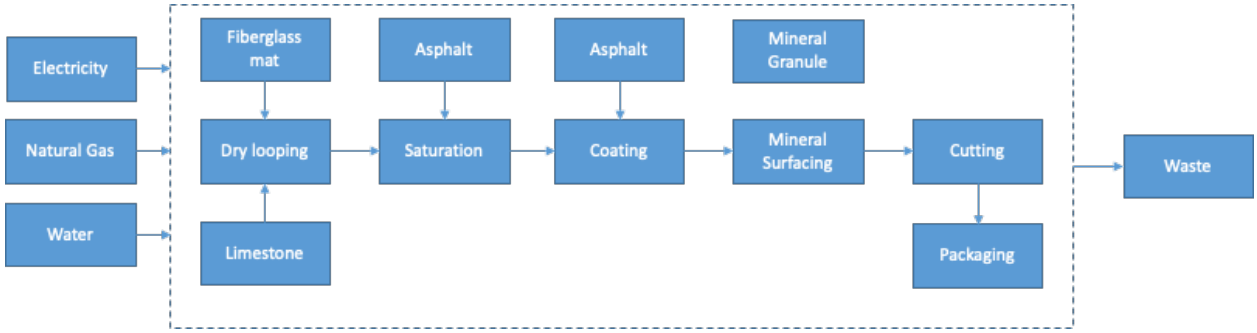


Figure 1: Manufacturing of GAF Timberline® HDZ™

Environment and Health During Manufacturing

During the manufacturing of GAF Timberline® HDZ™ shingles, all legal regulations regarding emissions to air, wastewater discharge, solid waste disposal and noise emissions are followed.

Packaging

After manufacturing, the product is prepared for shipment to the customer. The primary packaging covering each bundle of shingles is shrink wrap. The product is then shipped on wooden pallets to the customer. Each pallet contains 52 or 36 bundles depending on the type of shipment. See Table 7 for packaging types and amounts.

Product Installation

Product installation utilizes fasteners for mechanical bond. For the best wind performance, the installation instruction recommends enhanced nailing pattern which uses 6 nails per shingle (41 nails per declared unit). When installed in low-temperature locations, hand-sealing will be necessary as the self-sealant on the shingle requires sufficient heat to activate, otherwise leading to compromised performance. For hand-sealing, 4 quarter-sized dabs of asphalt plastic cement will be applied on the back of each shingle. As a conservative estimate, this EPD considers enhanced nailing pattern and hand-sealing. The asphalt plastic cement used in the study is based on GAF's Matrix 203 Plastic Roof Cement.

Products must be installed in full compliance with manufacturer's written instructions, which are printed on the packaging of the products. Installation equipment is required though not included in the study as these are multi-use tools and the impacts per declared unit is considered negligible. Packaging waste is generated and disposed of in this stage.

Reference Service Life

This EPD does not consider the use phase. As such, no RSL is declared.

Extraordinary Effects

Fire

Resistance by the roofing system to fire applied to the exterior roof surface is important. GAF Timberline® HDZ™ has a class A fire rating (highest rating).

Water

There are no extraordinary effects on the environment due to the application of water on the product.

Mechanical Destruction

GAF Timberline® HDZ™'s wind rating is 130 mph. Other specifications can be found at https://www.gaf.com/en-us/products/timberline-hdz-shingles/specifications.

Re-Use Phase and Disposal

The energy input for deconstruction is assumed to be insignificant for asphalt shingles according to the PCR Part B. The two components being disposed are fasteners (metal) and asphalt shingles (product). For metals disposed in the United States, 85% is recycled and 15% is landfilled, while those non-metal materials are 100% landfilled.

Further information

More information about GAF and its products can be found at www.gaf.com.

Declared Unit

The declared unit according to the PCR is 1 square meter. Table 3 show additional details related to the declared unit.

Table 3: Declared Unit Details

	HDZ™	Unit
Declared unit	1	m^2
Mass per declared unit, excluding fasteners	9.83	kg
Fasteners	8.62E-02	kg
Asphalt plastic cement	1.76E-02	kg
Thickness*	2.41 - 2.67 at single ply portion 4.83 - 5.21 at the dragon tooth	mm
*For asphalt shingles, the thickness is not specified or required by applicable codes.		

System Boundary

A summary of the life cycle stages included in this LCA is presented in Table 4.

Table 4: Summary of Included Life Cycle Stages

Module Name	Description	Analysis Period	Summary of Included Elements
A1	Product Stage: Raw Material Supply	2019	Raw Material sourcing and processing as defined by secondary data.
A2	Product Stage: Transport	2019	Shipping from supplier to manufacturing sites. Fuel use requirements estimated based on product weights and estimated distance.
A3	Product Stage: Manufacturing	2018	Energy, water and material inputs required for manufacturing products from raw materials. Packaging materials and manufacturing waste are included as well.
A4	Construction Process Stage: Transport	2019	Shipping from manufacturing site to project site. Fuel use requirements estimated based on product weights and default distance provided in PCR.
A5	Construction Process Stage: Installation	2019	Installation materials and packaging material waste.
B1	Use Stage: Use	N/A	Module not declared (MND)
B2	Use Stage: Maintenance	N/A	Module not declared (MND)
B3	Use Stage: Repair	N/A	Module not declared (MND)
B4	Use Stage: Replacement	N/A	Module not declared (MND)
B5	Use Stage: Refurbishment	N/A	Module not declared (MND)
B6	Operational Energy Use	N/A	Module not declared (MND)
B7	Operational Water Use	N/A	Module not declared (MND)
C1	EOL: Deconstruction	2019	No inputs required for deconstruction.
C2	EOL: Transport	2019	Shipping from project site to landfill. Distance assumed to be 100 miles from installation site to landfill as per PCR.
C3	EOL: Waste Processing	2019	Waste processing not required. All waste can be processed as is.
C4	EOL: Disposal	2019	The disposal process of the product varies with the material type as per Part A Section 2.8.5. The impacts from landfilling and recycling are modeled based on secondary data.
D	Benefits beyond system	N/A	Module not declared (MND)

Cut-Off Rules

All inputs for which data were available were included. Material inputs greater than 1% (based on total mass of the final product) were included within the scope of analysis. Material inputs less than 1% were included if sufficient data were available to warrant inclusion. Cumulative excluded material inputs and environmental impacts are less than 5% based on total weight of the declared unit. There is no excluded material or energy input or output except below:

- Siloxane (0.03%)—The material was cut off for the lack of appropriate data, but the mass of this flow is accounted.
- As the tools used during the installation of the product are multi-use tools and can be reused after each installation, the per-declared unit impacts are considered negligible and therefore are not included.

Estimates and Assumptions

The compositional data of GAF Timberline® HDZ™ are based upon typical product performance and is subject to normal manufacturing tolerance and variance. This EPD is based on nominal values. Some estimates and assumptions that may have affected the study are:

- For the best wind performance, enhanced nailing pattern was adopted in the study to model the installation stage. This is an overestimate for the average installed product, but it was deemed appropriate to include the results of the highest impact installation method.
- Infrastructure flows have been excluded.

- The manufacturer provided recommendations on material, type and specs of the fastener to be used in the installation. In the study, 11-ga steel nail with a count of 221 per lb was assumed to be used for modeling. This specification meets the requirement in the installation instruction.
- As per PCR Part B, the installation and deconstruction stages do not use significant energy.
- No installation waste is generated given the LayerLock Technology of the products which enables up to 99.9% nailing accuracy. (Results based on study conducted by Home Innovation Research Labs, an independent research lab, comparing installation of Timberline HD Shingles to Timberline HDZ Shingles on a 16-square roof deck using standard 4-nail nailing pattern under controlled laboratory conditions. Actual results may vary.)
- PCR Part A does not provide the waste disposal pathway for wood packaging waste. The scenario of pulp is used instead.
- The inclusion of overhead energy, water and waste data was determined appropriate due to the limited energy tracking capabilities of GAF.
- The use and selection of secondary datasets from GaBi – The selection of which generic dataset to use to represent an aspect of a supply chain is a significant value choice. Collaboration between LCA practitioner, GAF associates and GaBi data experts was valuable in determining best-case scenarios in the selection of data.

Background data

Primary data were collected onsite by GAF associates. This includes electrical and thermal energy, water consumption, waste generation, bill of materials and suppliers. Secondary data including those used to complete the upstream material LCI background data were sourced from GaBi Database (Version 9.2.0.58), Service Pack 40 and eGRID.

Data Quality

The geographical scope of the manufacturing portion of the life cycle is ten facilities across the US. Site-specific data are collected, and the average are weighted based on the production at each facility. All primary data were collected by the manufacturing facilities. The geographic coverage of primary data is considered excellent. The primary data provided by the manufacturer represent all information for calendar year 2018. Using this data meets the PCR requirements. Time coverage of this data is considered good. Primary data provided by the manufacturer are specific to the technology that GAF uses in manufacturing their product. It is site-specific and considered of good quality. It is worth noting that the energy and water used in manufacturing the product includes overhead energy such as lighting, heating and sanitary use of water. Sub-metering would improve the technological coverage of data quality. Data necessary to model cradle-to-gate unit processes were sourced from GaBi LCI datasets. The data included are considered complete, though appropriate proxies were utilized for geological materials, not affecting data quality. The LCA model included all known material and energy flows, with the exception of what is listed in Cut-off Rules.

Period under Review

Data used in this study were representative of production in calendar year 2018.

Allocation

General principles of allocation were based on ISO 14040/44. Allocation was done on a physical mass basis to determine per-unit impacts of manufacturing.

Comparability

The user of the EPD should take care when comparing EPDs from different companies. Assumptions, data sources, and assessment tools may all impact the uncertainty of the final results and make comparisons misleading. Even for similar products, differences in use and end-of-life stage assumptions and data quality may produce incomparable results. The user should not compare EPDs unless they are experts in the nuances of Life Cycle Assessment (LCA) practice and methodology and follow comparability best practices.

Scenarios and Additional Technical Information

Transportation to the Construction Site (A4)

Table 5: Transportation Details

Name	Value	Unit
Fuel Type	Diesel	-
Liters of Fuel	38.81	l/100km
Vehicle Type	Truck – Trailer, basic enclosed/45,000 lb. payload	
Transport distance	800	km
Capacity Utilization	78	%
Weight of Products Transported	1.01E+01	kg
Capacity Utilization Volume Factor	1	-

Table 6: End-of-Life Parameters

	HDZ™	Unit
Assumptions for scenario development	As per PCR Part B, the energy use of the deconstruction of asphalt shingles is not significant. The deconstructed product is collected with mixed construction waste. As required by the PCR Part A, the non-metal waste is 100% landfilled, while the metal waste is 85% recycled and 15% landfilled.	
Collected as mixed construction waste	9.93	kg
Non-metal Landfilling 100%	9.85	kg
Metal Waste Recycling (85%)	7.33E-02	kg
Metal Waste Landfilling (15%)	1.29E-02	kg
Removals of biogenic carbon (excluding packaging)	1.12E-01	kg CO_2

Installation into the Building (A5)

Table 7: Installation Parameters

Name	Value	Unit
Nail	8.62E-02	kg
Asphalt Plastic Cement	1.76E-02	kg
Net freshwater consumption specified by water source and fate	0	m^3
Other resources	0	kg
Electricity consumption	0	kg
Other energy carriers	0	MJ
Production loss per declared unit	0	kg
Waste material at the construction site before waste processing, generated by product installation	1.87E-01	kg
Plastic Recycling (15%)	3.19E-03	kg
Plastic Landfilling (68%)	1.45E-02	kg
Plastic Incineration (17%)	3.62E-03	kg
Total Plastic Packaging Waste	2.13E-02	kg
Wood Recycling (75%)	1.24E-01	kg
Wood Landfilling (20%)	3.31E-02	kg
Wood Incineration (5%)	8.27E-03	kg
Total Wood Packaging Waste	1.65E-01	kg
Biogenic carbon contained in packaging	3.22E-01	kg CO_2
Direct Emission to ambient air, soil, and water	0*	kg
VOC emission	Unknown**	µg/m^3

*According to the SDS of the asphalt, it is not volatile at ambient temperature and pressure.

** The products are not intended to be installed indoors, therefore no indoor air quality testing has been performed

LCA Results

All results are given per declared unit, which is one square meter corresponding to the amount of asphalt shingles being manufactured during calendar year 2018 for one square meter of constructed area.

The results do not cover the Use Phase and thus the benefits from utilizing the products cannot be demonstrated via this study. Environmental impacts were calculated using the GaBi software platform. Impact results have been calculated using both TRACI 2.1 and CML 2001-Jan 2016 characterization factors.

Table 8: Description of the System Boundary

Product Stage			Construction Process Stage		Use Stage							End of Life Stage				Benefits beyond system
Raw Material Supply	Transportation	Manufacturing	Transportation	Installation	Use	Maintenance	Repair	Refurbishment	Replacement	Operational Energy Use	Operational Water Use	De-construction	Transportation	Waste Processing	Disposal	Benefits beyond system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	MND

An X in the table above signifies that a module was included in the life cycle assessment. MND stands for Module Not Declared and signifies that a life cycle stage was not evaluated in the life cycle assessment.

Impact Category Keys

Table 9: LCIA Indicators

Abbreviation	Parameter	Unit
CML 2001-Jan 2016		
ADP-element	Abiotic depletion potential for non-fossil resources	kg Sb eq
ADP-fossil	Abiotic depletion potential for fossil resources	MJ, net calorific value
AP	Acidification potential of soil and water	kg SO_2 eq
EP	Eutrophication potential	kg Phosphate eq
GWP	Global warming potential	kg CO_2 eq
ODP	Depletion of stratospheric ozone layer	kg CFC_{11} eq
POCP	Photochemical ozone creation potential	kg Ethene eq
TRACI 2.1*		
AP	Acidification potential of soil and water	kg N eq
EP	Eutrophication potential	kg SO_2 eq
GWP	Global warming potential	kg CO_2 eq
ODP	Depletion of stratospheric ozone layer	kg CFC_{11} eq
Resources	Depletion of non-renewable fossil fuels	MJ, surplus energy
POCP	Photochemical ozone creation potential	kg O_3 eq

Table 10: Life Cycle Inventory Indicators

Abbreviation	Parameter	Unit
Resource Use Parameters		
RPR_E	Renewable primary energy as energy carrier	MJ, net calorific value
RPR_M	Renewable primary energy resources as material utilization	MJ, net calorific value
RPR_T	Total Renewable primary energy	MJ, net calorific value
$NRPR_E$	Non-renewable primary energy as energy carrier	MJ, net calorific value
$NRPR_M$	Non-renewable primary energy as material utilization	MJ, net calorific value
$NRPR_T$	Total Non-renewable primary energy	MJ, net calorific value
SM	Use of secondary material	kg
RSF	Use of renewable secondary fuels	MJ, net calorific value
NRSF	Use of non-renewable secondary fuels	MJ, net calorific value
RE	Recovered energy	MJ, net calorific value
FW	Use of fresh water	m^3
Output Flows and Waste Parameters		
HWD	Hazardous waste disposed	kg
NHWD	Non-hazardous waste disposed	kg
HLRW	High-level radioactive waste disposed	kg
ILLRW	Intermediate and low-level radioactive waste disposed	kg
CRU	Components for reuse	kg
MFR	Materials for recycling	kg
MER	Materials for energy recovery	kg
EE	Exported energy	MJ

*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.

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. Third party verified ISO 14040/44 secondary LCI data sets contribute more than 67% of total impacts.

Table 11: Carbon Update and Emissions Indicators

Parameter	Parameter	Unit
BCRP	Biogenic Carbon Removal from Product	[kg CO_2]
BCEP	Biogenic Carbon Emission from Product	[kg CO_2]
BCRK	Biogenic Carbon Removal from Packaging	[kg CO_2]
BCEK	Biogenic Carbon Emission from Packaging	[kg CO_2]
BCEW	Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	[kg CO_2]
CCE	Calcination Carbon Emissions	[kg CO_2]
CCR	Carbonation Carbon Removals	[kg CO_2]
CWNR	Carbon Emissions from Combustion of Waste from Non- Renewable Sources used in Production Processes	[kg CO_2]

Timberline® HDZ™ Shingles

CML Results

Impact Category	Product Stage	Construction Stage		Use Stage							End of Life Stage				Beyond system boundary
	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
ADP-elements [kg Sb eq]	1.95E-06	1.08E-07	1.57E-05	MND	MND	MND	MND	MND	MND	MND	0.00E+00	2.02E-08	0.00E+00	8.26E-08	MND
ADP-fossil fuel [MJ]	1.46E+02	8.94E+00	4.37E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.67E+00	0.00E+00	6.19E+00	MND
AP [kg SO2 eq]	9.84E-03	7.94E-04	8.87E-04	MND	MND	MND	MND	MND	MND	MND	0.00E+00	2.77E-04	0.00E+00	1.64E-03	MND
EP [kg Phosphate eq]	1.22E-03	2.15E-04	1.52E-04	MND	MND	MND	MND	MND	MND	MND	0.00E+00	7.39E-05	0.00E+00	2.06E-04	MND
GWP [kg CO2 eq]	3.88E+00	6.31E-01	5.05E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.18E-01	0.00E+00	3.88E-01	MND
ODP [kg CFC 11 eq]	1.16E-11	8.12E-17	2.12E-15	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.52E-17	0.00E+00	1.33E-15	MND
POCP [kg Ethene eq]	1.19E-03	-1.64E-04	1.99E-04	MND	MND	MND	MND	MND	MND	MND	0.00E+00	-9.61E-05	0.00E+00	1.45E-05	MND

TRACI Results

Impact Category	Product Stage	Construction Stage		Use Stage							End of Life Stage				Beyond system boundary
	A1-A3	A4	A5	B1	D	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
AP [kg SO2 eq]	1.09E-02	1.03E-03	1.17E-03	MND	MND	MND	MND	MND	MND	MND	0.00E+00	3.74E-04	0.00E+00	1.80E-03	MND
EP [kg N eq]	7.59E-04	1.64E-04	8.94E-05	MND	MND	MND	MND	MND	MND	MND	0.00E+00	4.23E-05	0.00E+00	1.03E-04	MND
GWP [kg CO2 eq]	3.88E+00	6.31E-01	5.05E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.18E-01	0.00E+00	3.88E-01	MND
ODP [kg CFC 11 eq]	1.23E-11	8.12E-17	2.12E-15	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.52E-17	0.00E+00	1.33E-15	MND
Resources [MJ]	1.88E+01	1.20E+00	3.33E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	2.24E-01	0.00E+00	8.03E-01	MND
POCP [kg O3 eq]	1.77E-01	2.25E-02	1.32E-02	MND	MND	MND	MND	MND	MND	MND	0.00E+00	8.41E-03	0.00E+00	3.17E-02	MND

Resource Use

Impact Category	Product Stage	Construction Stage		Use Stage							End of Life Stage				Beyond system boundary
	A1-A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
RPR_E [MJ]	7.67E+00	3.80E-01	4.68E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	7.10E-02	0.00E+00	5.12E-01	MND
RPR_M [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
RPR_T [MJ]	7.67E+00	3.80E-01	4.68E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	7.10E-02	0.00E+00	5.12E-01	MND
$NRPR_E$ [MJ]	1.52E+02	9.00E+00	4.57E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.68E+00	0.00E+00	6.33E+00	MND
$NRPR_M$ [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
$NRPR_T$ [MJ]	1.52E+02	9.00E+00	4.57E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.68E+00	0.00E+00	6.33E+00	MND
SM [kg]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
RSF [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
NRSF [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
RE [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
FW [m3]	1.38E-02	1.69E-03	6.44E-04	MND	MND	MND	MND	MND	MND	MND	0.00E+00	3.16E-04	0.00E+00	8.99E-04	MND

Output and Waste Flow

Impact Category	Product Stage	Construction Stage		Use Stage							End of Life Stage				Beyond system boundary
	A1-A3	A4	A5	B1	D	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
HWD [kg]	5.52E-06	1.54E-07	3.99E-09	MND	MND	MND	MND	MND	MND	MND	0.00E+00	2.88E-08	0.00E+00	4.23E-08	MND
NHWD [kg]	3.25E-01	6.45E-04	1.27E-01	MND	MND	MND	MND	MND	MND	MND	0.00E+00	1.21E-04	0.00E+00	9.48E+00	MND
HLRW [kg]	2.51E-06	2.44E-08	8.95E-08	MND	MND	MND	MND	MND	MND	MND	0.00E+00	4.57E-09	0.00E+00	6.25E-08	MND
ILLRW [kg]	2.13E-03	2.02E-05	7.83E-05	MND	MND	MND	MND	MND	MND	MND	0.00E+00	3.78E-06	0.00E+00	5.36E-05	MND
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
MER [kg]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND
EE [MJ]	0.00E+00	0.00E+00	0.00E+00	MND	MND	MND	MND	MND	MND	MND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	MND

Biogenic Carbon Removals and Emissions

Parameter	HDZ™	Unit
BCRP	1.12E-01	[kg CO_2]
BCEP	9.41E-02	[kg CO_2]
BCRK	3.22E-01	[kg CO_2]
BCEK	1.11E-01	[kg CO_2]
BCEW	0.00E+00	[kg CO_2]
CCE	0.00E+00	[kg CO_2]
CCR	0.00E+00	[kg CO_2]
CWNR	0.00E+00	[kg CO_2]

Interpretation

Overall for the HDZ Shingles, Global Warming Potential and Abiotic Depletion Potential of fossil resources are seen to be the most relevant impact categories, relative to global emissions. Within the impact categories, the vast majority of impacts result from the Production Phase (A1-A3), which represents 87% and 70% of the ADP-fossil and GWP, respectively. Asphalt is a major contributor to ADP-fossil and is also the second contributor for GWP among all the major materials. Improvement may be achieved by reducing the use of asphalt or using asphalt with recycled content, assuming the performance properties can still be achieved. With the purpose of driving down the GWP impacts of the products, the GWP intensity (fiberglass mat > asphalt > mineral granulate > limestone) sequence may be considered when optimizing the material composition.

References

1. Life Cycle Assessment, LCA Report for GAF – Timberline HDZ Shingles, Timberline Cool Series Shingles, WAP Sustainability Consulting, July 2020
2. ISO 14044: 2006 Environmental Management – Life cycle assessment – Requirements and Guidelines.
3. ISO 14025: 2006 Environmental labels and declarations – Type III environmental declarations – Principles and Procedures.
4. ISO 14044: 2006/ Amd 1:2017 Environmental Management – Life cycle assessment – Requirements and Guidelines – Amendment 1.
5. ISO 21930: 2017 Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services.
6. Product Category Rules for Environmental Product Declarations - Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing EPD Requirements (UL 10010-11)
7. GaBi Software Database Service Pack 39, thinkstep, 2019.
8. GaBi Dataset Search, thinkstep. Available at http://www.gabi-software.com/america/databases/gabi-data-search/
9. CML-IA Characterization Factors. 5 September 2016. https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors
10. Bare, J.C., G.A. Norris, D.W. Pennington, and T. McKone (2003). TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. Journal of Industrial Ecology 6(3), pp. 49-78.
11. Bare, J., TRACI 2.0: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.0. Clean Technologies and Environmental Policy 2011, 13, (5).
12. NSF Program Operator Rules, NSF International. February 23, 2015. https://www.nsf.org/newsroom_pdf/NSF_Program_Operator_Instructions-news.pdf