ENVIRONMENTAL PRODUCT DECLARATION

ASPHALT SHINGLE ROOFING SYSTEM

INSTALLATION: FASTENED

Steep-slope roofing system installed with fasteners and consisting of asphalt shingles, underlayment, leak barrier, starter strip, and hip and ridge components.

ASPHALT ROOFING MANUFACTURERS ASSOCIATION

The Asphalt Roofing Manufacturers Association (ARMA) is a trade association representing North America's asphalt roofing manufacturing companies and their raw material suppliers. The association includes the majority of North American manufacturers of asphalt shingles and asphalt low slope roof membrane systems. Information that ARMA gathers on modern asphalt roofing materials and practices is provided to building and code officials, as well as regulatory agencies and allied trade groups. Committed to advances in the asphalt roofing industry, ARMA is proud of the role it plays in promoting asphalt roofing to those in the building industry and to the public.

ARMA's vision and mission is to be an association committed to the long-term sustainability of the asphalt roofing industry and to advocate and advance the interests of the asphalt roofing industry by leveraging the collective expertise of its members.

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

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	Asphalt Roofing Manufacturers Association (ARMA)
DECLARATION NUMBER	4787168709.101.1
DECLARED PRODUCT	Asphalt Shingle Roofing System
REFERENCE PCR	ASTM: Asphalt shingles, built-up and modified bituminous membrane roofing. 2014
DATE OF ISSUE	October 28, 2016
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:	ASTM International Chair: Francois Charron-Doucet cert@astm.org
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

Participating Members

The following ARMA members provided data for the product covered within this document:

Atlas Roofing
www.atlasroofing.com

IKO
www.iko.com

Building Products of Canada
www.bpcan.com

Malarkey Roofing
www.malarkeyroofing.com

CertainTeed
www.certainteed.com

Owens Corning
www.owenscorning.com

GAF
www.gaf.com

PABCO
www.pabcoroofing.com

Product Definition

Product Description

The steep-slope roofing system included in this study consists of asphalt shingles, underlayment, leak barrier, starter strip, and hip and ridge components.

Component	Specification	Description
Asphalt shingles	ASTM D3018 Type I, D3462; CSA A123.5	- Asphalt shingles consist of fiberglass mat impregnated and coated on both sides with filled asphalt and surfaced on the exposed-to-weather portion with mineral granules. Asphalt shingles are self-sealing. - Primary weather barrier
Underlayment	ASTM D226, D4869; CSA 123.3	- Underlayment consists of organic felt saturated with asphalt - Helps prevent moisture from penetrating to the roof structure
Leak barrier	ASTM D1970; CSA A123.22	- Leak barriers consist of fiberglass mat impregnated and coated with polymer-modified asphalt - Helps prevent moisture from penetrating to the roof structure
Starter strip	ASTM D3018 Type I, D3462; CSA A123.5	- Starter strips consist of fiberglass mat impregnated and coated with asphalt - Creates a starter row when first installing roofing system. Starter strips are self-sealing. - Provides double layer coverage for first course and 2 inch headlap, and helps prevent wind blow-off of shingles

Component	Specification	Description
Hip and ridge	ASTM D3018 Type I, D3462; CSA A123.5	- Hip and ridge shingles consist of fiberglass mat impregnated and coated with asphalt. Hip and ridge shingles are self-sealing. - Installed on the hips and ridges of a steep-slope roof

Manufacturing Locations

The components of the steep-slope asphalt shingle roofing system are manufactured in the United States and/or Canada.

Applications and Uses

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 shingles provide a winning combination of beauty, affordability and reliability. They are available in a variety of colors, textures and styles to fit many unique designs, and offer a long service life. Asphalt shingle roofing systems provide protection against wind, rain, snow and extreme temperatures.

System Description

Material Content

Table 1 shows the input materials for manufacturing of asphalt shingles, underlayment, leak barrier, starter strip, and hip and ridge components; and the weight percentages of the components in the product system.

Table 1: Average material inputs for asphalt shingle, underlayment, leak barrier, starter strip, and hip and ridge manufacturing

Material Inputs*	Weight Percentage in Individual Component
Asphalt Shingle (89% of representative roofing system)	
Mineral stabilizers	38%
Mineral granules	34%
Asphalt	16%
Sand	8%
Fiberglass mat	2%
Laminating adhesive	1%
Sealant	<1%
Styrene butadiene styrene (SBS) polymer	<1%
Underlayment (5% of representative roofing system)	
Organic felt (paper, cardboard)	50%
Asphalt	50%

Material Inputs*	Weight Percentage in Individual Component
Leak Barrier (1% of representative roofing system)	
Asphalt	47%
Mineral stabilizers	18%
Mineral granules	15%
Sand	10%
Fiberglass mat	5%
Styrene butadiene styrene (SBS) polymer	3%
Polyolefin film	2%
Starter Strip (1% of representative roofing system)	
Mineral stabilizers	42%
Mineral granules	27%
Asphalt	21%
Sand	8%
Fiberglass mat	2%
Sealant	<1%
Styrene butadiene styrene (SBS) polymer	<1%
Hip and Ridge (2% of representative roofing system)	
Mineral granules	39%
Mineral stabilizers	35%
Asphalt	18%
Sand	5%
Fiberglass mat	2%
Sealant	1%
Styrene butadiene styrene (SBS) polymer	<1%

*Total system also includes weight of ancillary materials used during installation

Manufacturing Process

Fiberglass Asphalt Shingle (laminated shingle, starter strip, and hip and ridge)

Manufacture of fiberglass asphalt shingles, starter strips, and hip and ridge shingles begins with impregnation and coating of a fiberglass mat with a filled asphalt coating. The filled coating mixture is produced in a separate process that involves mixing oxidized asphalt and mineral stabilizer in appropriate proportions. Colored mineral granules are added to the top surface on areas that will be exposed in the installed condition. Other granules, typically referred to as headlap granules, are added to the top surface of the impregnated fiberglass mat on areas that will not be exposed in the installed condition. A parting agent is added to the bottom surface to facilitate separation of the shingles during installation. An asphalt-based adhesive is applied to the finished shingle and serves to bond individual shingles to each other after installation. In the case of multi-layer shingles, the individual layers are combined during manufacturing using a laminating adhesive. Finally, the shingle is cut to size and packaged for shipment.

The thickness of the wide variety of roofing shingles, starter strip shingles, and hip and ridge shingles on the market can vary substantially. Manufacturers do not report the thickness of any type of shingle.

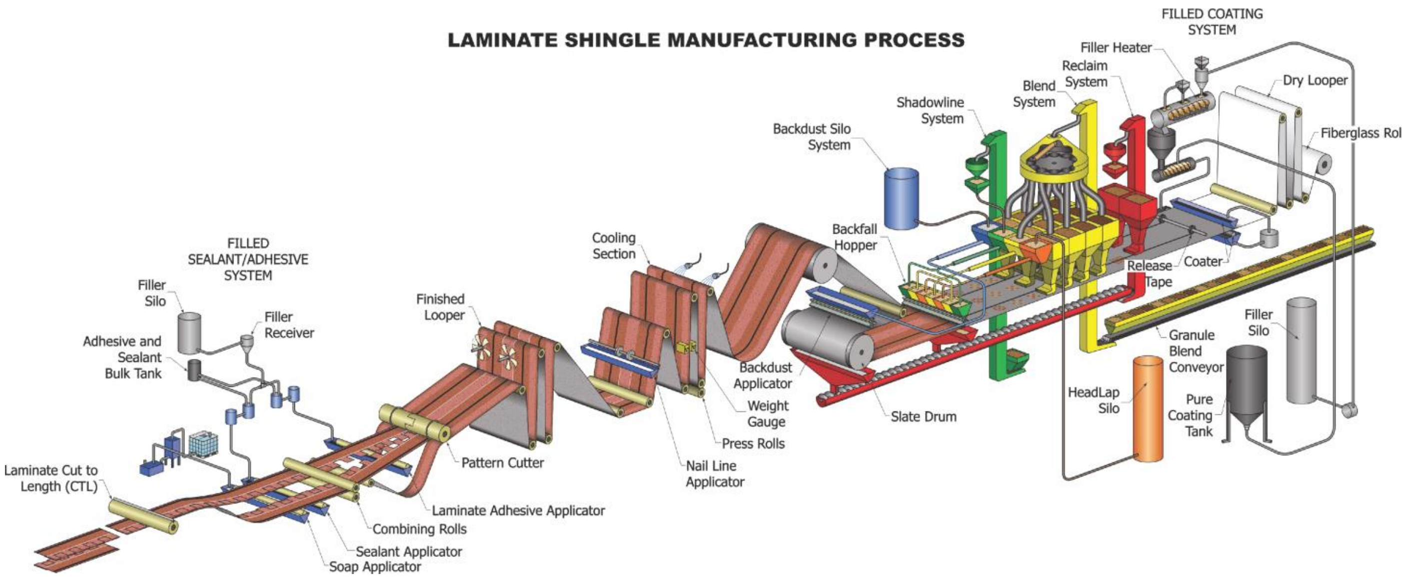

Figure 1: Laminate shingle production diagram

Underlayment (saturated organic felt)

Saturated organic felt underlayment manufacturing involves production of an organic felt mat that typically incorporates paper, cardboard, and sawdust. In a separate process, the organic felt mat is saturated with non-oxidized or lightly oxidized asphalt. The product is cooled and wound into rolls and packaged for shipment.

Leak Barrier

Leak barrier manufacture involves impregnating and coating a fiberglass mat with a polymer-modified asphalt. The polymer-modified asphalt is produced by mixing appropriate proportions of polymer, non-oxidized or lightly oxidized asphalt, and limestone or other suitable mineral stabilizer. A fine mineral or film surfacing is applied to one side and a removable release liner to the other side. Some products incorporate a narrow strip of permanently attached or removable film along one edge to facilitate connection to overlapping sheets during installation. The product is cooled, wound into rolls, and packaged for shipment.

Installation

For this EPD, the installation of a steep-slope roofing system begins with the attachment of leak barrier at eaves and other locations where ice dams are likely. This is followed by the application of underlayment to the roof deck with approved fasteners. Next, a starter strip is fastened to the roof along the eave edge. Flashing and vents are installed as needed. Shingles are then installed with nails starting from the eave edge to the ridge of the roof. Finally, hip and ridge shingles are installed at hips and ridges.

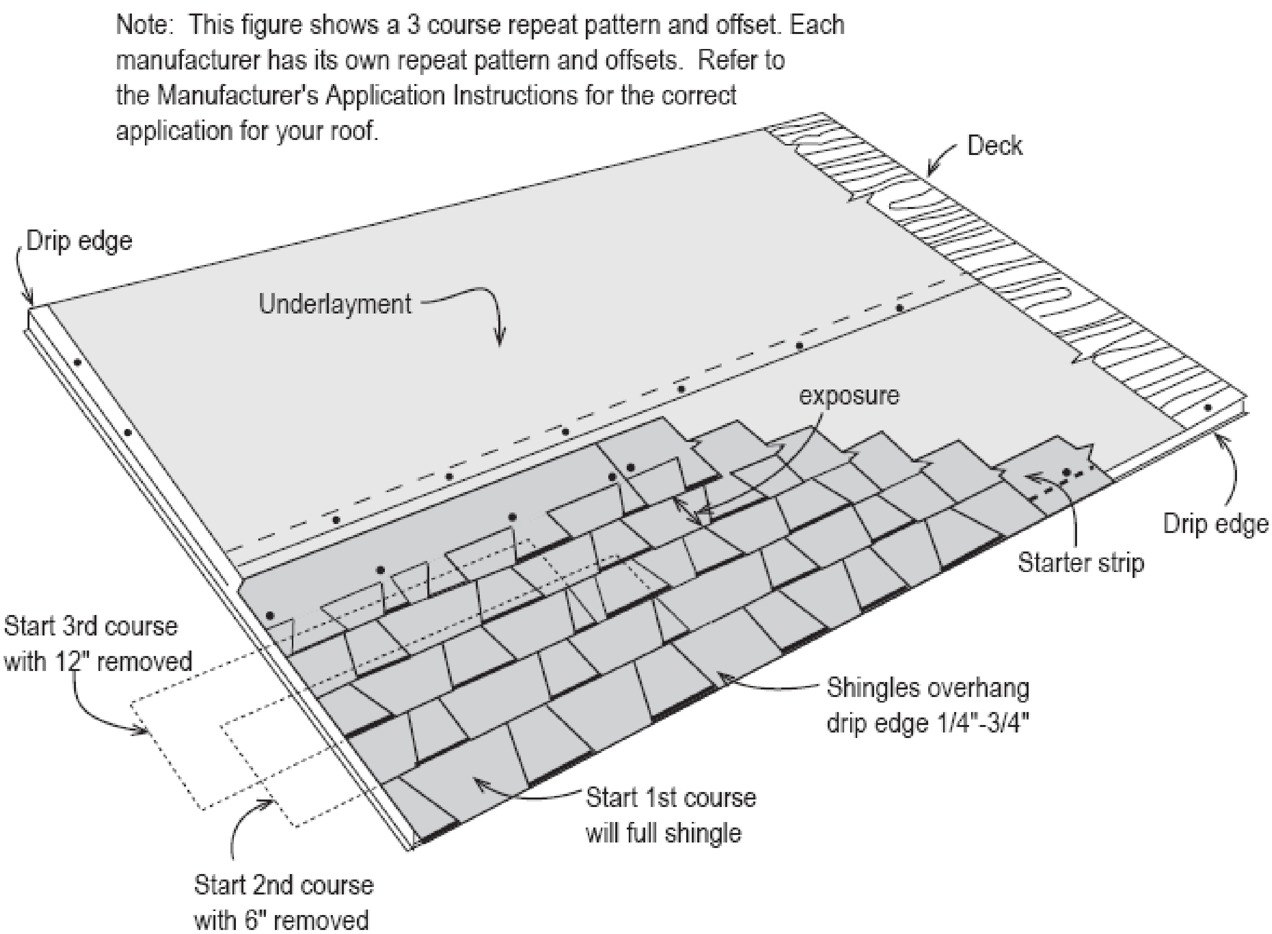

Figure 2: Asphalt Shingle roofing system installation detail

The table below lists components of a typical steep-slope system. The effective coverage includes the required overlap of sheets while the scrap rate accounts for material wasted during installation. More details on general steep-slope installation can be found in the ARMA Asphalt Roofing Residential Manual.

Table 2: Roofing system installation inputs and outputs, per 1 m^2

	Weight of Material [kg / m^2]	Effective Coverage [m^2 of Material / 1 m^2 of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m^2]
Inputs				
Shingles	4.8	2.35	2%	11.6
Underlayment	0.6	1.08	0.25%	0.66
Leak Barrier	1.7	0.10	1%	0.17
Starter Strip	5.5	0.03	1%	0.17
Hip and Ridge	6.4	0.03	1%	0.19

	Weight of Material [kg / m²]	Effective Coverage [m² of Material / 1 m² of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m²]
Flashing	0.049	N/A	-	0.049
Vents	0.098	N/A	-	0.098
Nails[1]	0.064	N/A	-	0.064
Outputs				
Installed System				12.7
Waste				0.25

[1] 280 units per square

End-of-Life

At the end-of-life, the steep-slope roofing system is removed by manual labor. Shingles and underlayment are removed beginning at the ridge of the roof with a tear-off tool or roofing shovel. The debris is collected and transported off-site via truck. The waste is brought to a landfill.

Life Cycle Assessment – Product Systems and Modeling

Declared Unit

The declared unit of this study is 1 m^2 (10.8 ft^2) of the installed roofing system. The associated reference flow (the quantity of material required to fulfill the declared unit) is 12.7 kg/m^2.

Life Cycle System Boundaries

The life cycle study encompasses the cradle-to-gate production, construction, and end-of-life (EoL) stages of a steep-slope asphalt shingle roofing system, including raw material extraction and processing, product manufacturing and installation, plus material disposal at EoL. Transportation between stages is accounted for, including raw material transport to the manufacturing facility, finished product transport to the construction site, and transport of the roof system at EoL to the landfill. Use, maintenance, repair, or replacement of the roof system over a building's service life is not 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; as well as maintenance and operation of support equipment are all outside of the scope of the study.

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	MND	MND	MND	MND	MND	X	X	X	X

MND = module not declared

Assumptions

The analysis uses the following assumptions:

- Mineral granules can be made in a variety of colors, which affects the composition of the required mineral granule coating. White mineral granules were selected as a representative product for this study because the pigment used for white products, titanium dioxide, generally has a higher impact than other pigments; therefore, using white is a conservative assumption.
- Where a manufacturer was unable to calculate an average distance for the distribution of its final product from its facility, it provided a best estimate.
- Due to lack of data availability some proxy background data were used, specifically in the context of the geographical scope of the study.

Cut-off Criteria

No cut-off criteria were applied in this study. All reported data were incorporated and modeled using best available LCI data.

Transportation

Production-weighted averages for the transportation distances and modes of transport associated with each participating company are included for the transport of the raw materials to production facilities and the transport of the finished products to distribution centers. The transport of finished products from distribution center to the construction site and of waste from the construction site to landfill were each assumed to be 20 miles.

Temporal, Technological, and Geographical Coverage

Temporal: Primary data, collected from the participating ARMA member companies, is representative of the year 2012.

Technological: At least 75% of the production market is estimated to be represented within this study.

Geographical: The geographic coverage represented by this study is the United States and Canada, though some manufacturers source their raw materials from outside this region. Whenever US background data were not readily available, European data or global data were used as proxies, depending on appropriateness and availability. Results are presented as production weighted averages for the US and Canada.

Background Data

The LCA model was created using the GaBi ts Software system for life cycle engineering, developed by thinkstep AG (previously PE INTERNATIONAL). The GaBi 2013 database provides the LCI data for several of the raw and process materials obtained from the background system. Secondary data, information from relevant literature, are from a range of sources between 1977 (asphalt oxidation information) and 2013.

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 the GaBi 2013 databases. Allocation and other methodological choices were made consistently throughout the model.

Allocation

As several products are often manufactured at the same plant, participating companies used mass allocation to report data since the environmental burden in the industrial process (energy consumption, emissions, etc.) is primarily governed by the mass throughput of each sub-process.

All packaging waste generated during installation, as well as 40% of the wooden pallets used for shipping of products, are assumed to be sent to landfill and the system credited with any avoided production of electricity generated from the combustion of landfill gas.

The impacts due to the use of any recycled materials during manufacturing come only from further processing required during the recycling process. Where in-house recycling is used to create other products, co-product allocation by mass is used and any additional processing steps required for use of the recovered materials are accounted for. It is conservatively assumed that all roofing materials disposed at EoL are sent to landfill. This will vary from job site to job site as some roofers may recycle metal components and shingles.

Life Cycle Assessment – Results and Analysis

Environmental Product Declarations (EPDs) created under a different Product Category Rule (PCR) are not comparable. Additionally, EPDs based on a declared unit shall not be used for comparisons between products, regardless of the EPDs using the same PCR.

Use of Material Resources

The material resource consumption associated with the installed roofing system is presented below for the production, construction, and EoL stages. Water consumption values are negative due to waste sent to landfill at EoL. A landfill introduces blue water to the watershed because it collects rainwater during its lifetime that is eventually released back into the ground, therefore more blue water is coming out of the process than going in. Rainwater is not blue water and is therefore not included in the water consumption metric.

Table 3: Resource use results for each life cycle stage, per 1 m²

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Renewable materials	kg	25.7	0.9	1.5	**28.1**
Nonrenewable materials	kg	19.9	1.4	3.0	**24.3**
Water consumption	L	17.7	-1.2	-27.9	**-11.4**

Primary Energy by Life Cycle Stage

The primary energy demand associated with the installed roofing system is presented below for the production, construction, and EoL stages. Results are given as higher heating value (HHV), per the PCR. Renewable energy is negative for construction due to the credit given for reusing pallets.

Table 4: Primary energy demand results for each life cycle stage, per 1 m²

Primary Energy	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Nonrenewable fossil	MJ (HHV)	193	15.9	10.0	**219**
Nonrenewable nuclear	MJ (HHV)	4.1	0.3	0.3	**4.7**
Renewable (solar, wind, hydro, geo)	MJ (HHV)	7.2	-1.0	0.4	**6.6**
Renewable (biomass)	MJ (HHV)	3×10^{-11}	2×10^{-5}	7×10^{-12}	**2×10^{-5}**

Life Cycle Impact Assessment

The environmental impacts associated with the installed roofing system are presented below for the production, construction, and EoL stages.

Table 5: Life cycle impact category results, per 1 m² (TRACI 2.1)

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Global warming potential	kg CO_2-eq	5.1	1.3	0.6	**6.9**
Smog creation potential	kg O_3-eq	0.3	0.1	0.06	**0.5**
Acidification potential	kg SO_2-eq	0.02	0.005	0.003	**0.03**
Eutrophication potential	kg N-eq	0.002	4×10^{-4}	4×10^{-4}	**0.003**
Ozone depletion potential	kg CFC-11 eq	4×10^{-10}	5×10^{-9}	1×10^{-11}	**5×10^{-9}**

Waste Generation

The waste generation associated with the installed roofing system is presented below for the production, construction, and EoL stages.

Table 6: Waste generation results, per 1 m²

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Non hazardous waste generated	kg	0.8	0.3	12.8	**13.9**
Hazardous waste generated	kg	0.001	1×10^{-4}	2×10^{-4}	**0.002**

Additional Environmental Information

Shingle Recycling and Incineration

Shingle recycling is economically viable, convenient where available, and saves valuable resources from being sent to a landfill. Asphalt shingles are most commonly recycled into pavement, which offsets the need for new asphalt and aggregate. Additional uses continue to be explored. Asphalt shingle recycling can create jobs for recycling locations and reduce costs for paving. Recycling shingles also allows homeowners to make a positive environmental contribution.

When recycled into pavement the shingles are ground and screened to remove any auxiliary debris, such as nails. The ground product is mixed with aggregate prior to being blended with virgin paving asphalt binder, thus displacing virgin asphalt binder and aggregate. Development of processes to recycle asphalt shingles directly back into shingle production is currently under way, but has not achieved a commercial-scale, and therefore is not accounted for in the LCA results presented in this EPD.

Due to inherent impurities, asphalt shingles cannot be combusted in standard incineration plants and thus are combusted in cement kilns, replacing alternative fuels such as refinery fuel gas.

Reflective Roofs

Reflective roofs are defined as roofing products with high solar reflectance. Many in the construction industry define “cool roofs” as roofing products with high solar reflectance and high thermal emittance. Asphalt-based products have the inherent property of having high emittance, regardless of their reflective properties. Asphaltic roof systems typically have thermal emittance values greater than 0.80. Reflectance is a deliberate product characteristic, and varies based on the surfacing used.

There are reflective roof options available for virtually any roof and any building. Because of asphalt roofs’ longevity, asphalt-based products provide excellent value for homeowners and building owners by delivering superior durability and sustainability at reasonable cost.

Asphalt shingles provide options for varying levels of reflectivity. The reflectivity is related to the color of the asphalt shingles’ mineral granule surfaces. While cool roofs are an increasingly popular roof option, they represent one of many approaches to help building owners and consumers reduce building energy use and address contemporary environmental concerns.

Individual Component Results

The material resource consumption, primary energy demand, environmental impacts, and waste generation results associated with each individual component (excluding ancillary materials used during installation) of the roofing system are presented below for the production stage (A1-A3).

Table 7: Production stage (A1-A3) impact results for each system component, per 1 m^2 of individual component

Impact Category	Units	Asphalt Shingle	Underlayment	Leak Barrier	Starter Strip	Hip and Ridge
Renewable materials	kg	8.2	4.2	8.3	9.9	14.1
Nonrenewable materials	kg	7.8	0.4	2.4	7.7	11.3
Water consumption	L	5.5	3.8	3.7	6.1	7.9
Nonrenewable fossil	MJ (HHV)	61.2	19.4	57.7	81.1	95.9
Nonrenewable nuclear	MJ (HHV)	1.5	0.2	1.2	1.7	2.4
Renewable (solar, wind, hydro, geo)	MJ (HHV)	1.7	2.6	1.2	1.9	2.9
Renewable (biomass)	MJ (HHV)	9×10^{-12}	2×10^{-12}	5×10^{-12}	1×10^{-11}	1×10^{-11}
Global warming potential	kg CO^2-eq	1.7	0.6	1.5	2.0	2.9
Smog creation potential	kg O^3-eq	0.1	0.03	0.08	0.1	0.2
Acidification potential	kg SO^2-eq	0.008	0.002	0.006	0.009	0.01
Eutrophication potential	kg N-eq	6×10^{-4}	3×10^{-4}	5×10^{-4}	0.001	9×10^{-4}
Ozone depletion potential	kg CFC-11 eq	2×10^{-10}	2×10^{-11}	1×10^{-10}	2×10^{-10}	3×10^{-10}
Non hazardous waste generated	kg	0.3	0.01	0.07	0.2	0.3
Hazardous waste generated	kg	5×10^{-4}	9×10^{-5}	2×10^{-4}	6×10^{-4}	0.001

References

- Asphalt Roofing Manufacturers Association. “Residential Asphalt Roofing Manual Design and Application Methods.” 2014 Edition.
- ASTM (2014). “Product category rules for preparing an environmental product declaration for product group: Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing.” (http://www.astm.org/CERTIFICATION/DOCS/152.PCR_ASTM_Asphalt_Roofing_PCR_073114.pdf)
- LBP, University of Stuttgart and thinkstep GmbH, Leinfelden-Echterdingen (2013). GaBi 6 dataset documentation for the software-system and databases (http://documentation.gabi-software.com/)
- thinkstep (formerly PE INTERNATIONAL) (2015). “Life Cycle Assessment of Asphalt Roofing Systems: Cradle-to-grave LCAs of a steep-slope and four low-slope industry-average asphalt roofing systems.”

LCA Development

The EPD and background LCA were prepared by thinkstep, Inc. (previously PE INTERNATIONAL).

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