LIFE CYCLE ASSESSMENT (LCA) OF W. R. MEADOWS WATER-RESISTIVE AND AIR BARRIERS

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Authors Luyi Huang, Sustainable Minds

Kim Hammer, Sustainable Minds

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1 INTRODUCTION

1.1 Opportunity

W. R. MEADOWS is a well-established manufacturer in the concrete construction industry. It offers a wide range of products, from concrete protection and sealing solutions to expansion joints, concrete restoration, and moisture control systems. Sustainability and environmental responsibility lie at the heart of W. R. MEADOWS' operations, and the company continually integrates innovative and resource-efficient strategies into its processes and product offerings.

In response to the growing demand for transparency in the construction industry and to uphold its internal sustainability commitments, W. R. MEADOWS has embarked on an initiative to understand better the environmental impacts of its building envelope system product lines. This includes vapor barriers/retarders, waterproofing, and air and vapor barrier products. This effort involves conducting a cradle-to-gate life cycle assessment (LCA) to evaluate the environmental footprint of its products, focusing on stages from raw material acquisition to manufacturing. By utilizing plant-specific data from four manufacturing sites including Hampshire, IL; Ft Worth, TX; and Cartersville, GA;
W. R. MEADOWS aims to assess the potential environmental impacts of:

- Waterproofing membrane products MEL-ROL 60 Mil, LOW TEMP, and XLT
- Air barrier products
    - Sheet-applied AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING, LOW TEMP, and XLT
    - Fluid-applied AIR-SHIELD LMP, LSR, and TMP

This approach to LCA underscores the company's dedication to making informed decisions that support sustainable practices across its operations.

To enhance transparency and environmental communication, W. R. MEADOWS is interested in having Sustainable Minds Transparency Reports [EPDs]™ (TRs) for its waterproofing membrane, air barrier, and vapor barrier products. These TRs are ISO 14025 Type III [1] declarations can be used for communication with and amongst other companies, architects, and consumers, and can also be utilized in whole building LCA tools in conjunction with the LCA background report and life cycle inventory (LCI). This study conforms to the requirements of ISO 14044 [2], ISO 21930:2017 [3], and the NSF PCR for Water-Resistive and Air Barriers (Version 4) [4].

1.2 Life cycle assessment

LCA is performed to comprehensively explore, quantify, and interpret the potential environmental impacts associated with a product or service throughout its entire life cycle. A product's life cycle consists of various stages, starting from raw material acquisition and manufacturing to product use and maintenance, plus final product disposal. Depending on the inclusion and exclusion of life cycle stages, an LCA could be cradle to gate (from raw material acquisition to the manufactured product ready to be shipped), cradle to gate with options (which also optionally includes other modules such as shipment and installation), and cradle to grave (which includes all other stages including the use phase and disposal once the useful life is over).

Any LCA conducted with the intention of publishing EPDs needs to comply with the internationally accepted ISO 14040 and ISO 14040 standards. ISO 14040 provides principles and frameworks for conducting an LCA, while ISO 14044 specifies requirements and provides guidelines for an LCA. ISO 14040 sets out a four-phase methodology framework for completing a LCA, as depicted in Figure 1.

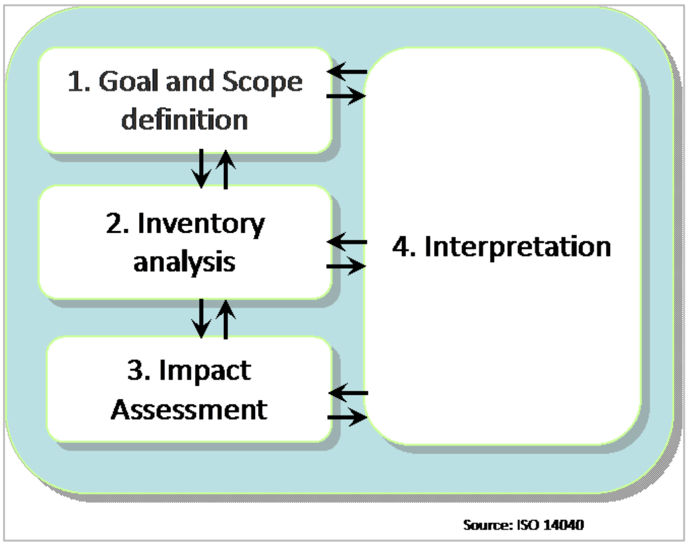

Figure 1. Phases of an LCA

- **Goal and scope definition:** Goals refer to establishing the purpose of the LCA, and they define the environmental aspects to be studied and the intended audience. Scope outlines the system boundaries, the functional unit of analysis, and the life cycle stages to be included. System boundaries set up inclusions and exclusions in an LCA. PCRs usually specify whether the boundary must be cradle-to-gate, cradle-to-installation, or cradle-to-grave.

- **Life cycle inventory analysis:** In this step, a detailed inventory of all the environmental inputs and outputs associated with each stage of the product's life cycle is compiled. Primary data about materials, energy, and emissions assessing the upstream supply chain, the company's manufacturing operations, and downstream processes (after the product leaves the factory gate) are collected via LCI data collection templates or tools. Annual data is suggested in most cases to be representative of the manufacturing operations. In the case of multi outputs, resources can be allocated to the product of interest via mass or volume, or as relevant. The inventory is then scaled to meet the functional unit of the LCA.

- **Life cycle impact assessment:** The compiled LCI is then modeled using LCA software like SimaPro, GaBi, openLCA, or others using suitable background data sets available in their databases. Each is assigned to categories according to different impact methodologies, and the software provides final impact values for those different environmental impact categories. Several LCIA methodologies exist in the market, including ReCiPe, TRACI, CML, and ILCD, which differ in terms of their approaches, characterization factors, evaluated impact categories, and modeling assumptions. Practitioners can choose a combination of LCIA methodologies to provide a holistic view of the environmental performance of a product.

- **Interpretation of results:** In this step, the LCIA results are analyzed and presented via an LCA report. This stage helps draw conclusions about the product's environmental performance, identify any environmental hotspots, make recommendations, and assess the significance of the findings. Sensitivity analysis, scenario studies, and uncertainty assessment are often included as a part of the interpretation to ensure the reliability and robustness of the results. LCA, if well interpreted and evaluated, presents a number of opportunities for the manufacturer in developing sustainability goals and initiatives.

This LCA study follows an attributional approach and uses a cradle-to-grave system boundary. This report incorporates LCA terminology. To assist the readers in understanding LCA, special attention has been given to list definitions of important terms used at the end of this report.

A critical review of the LCA and an independent verification of the TR are required for ISO14025 Type III environmental declarations. Both are included in this project.

1.3 Team

This LCA report is the outcome of efforts by the project team led by Kimberly A. Lombardozzi, Frank Bifero, Scott Cresta, and Burt Dougharty on behalf of W. R. MEADOWS. Sustainable Minds led the development of the LCA modeling, results, report, and Transparency Reports [EPDs]™.

1.4 Status

All information in this report reflects the best possible inventory by W. R. MEADOWS at the time it was collected, and Sustainable Minds and W. R. MEADOWS adhered to best practices in transforming the inventory into this report.

Primary data was provided for manufacturing activities from CY2023 from the W. R. MEADOWS facilities in [redacted]. Where data was missing, assumptions were made from manufacturing data for the facility based upon expertise from the W. R. MEADOWS plant manager and their upstream suppliers. This study also includes background data to complete the inventory and fill gaps where necessary.

This is a supporting LCA report for the W. R. MEADOWS TRs and was evaluated for conformance to the PCR according to the ISO 14025 and ISO 14040/14044 standards. The LCA review and verification of the Sustainable Minds Transparency Reports [EPDs]™ were carried out by Lindita Bushi, Ph.D., Athena Sustainable Materials Institute to determine conformance to ISO 14040/14044, ISO 21930:2017, and the relevant PCRs.

2 Goal and Scope

This chapter explains the goal and scope of the LCA study. The aim of the goal and scope is to define the product under study and the depth and breadth of the analysis.

2.1 Intended application and audience

This report aims to define the specific application of the LCA methodology to the life cycle of sheet-applied AIR-SHIELD (AIR-SHIELD and AIR-SHIELD THRU-WALL FLASHING, LOW TEMP, and XLT), fluid-applied AIR-SHIELD (LMP, LSR, and TMP), and MEL-ROL (60 Mil, LOW TEMP, and XLT). The report serves both internal and external purposes and is intended for a diverse audience. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCR, as well as W. R. MEADOWS' internal stakeholders involved in marketing and communications, operations, and design.

The results presented in this document are not meant to support comparative claims. The outcomes will be made available to the public in Sustainable Minds Transparency Reports [EPDs]™ (Type III environmental declarations per ISO 14025), which are intended for communication between businesses and consumers (B2C).

2.2 Product description

This LCA study covers several waterproofing, air, and vapor barrier products produced in four W. R. MEADOWS facilities across the United States. These products are essential to a well-performing building envelope because they enhance building durability, energy efficiency, and indoor air quality by preventing moisture intrusion and reducing the risk of mold or structural damage. Complete product descriptions for the covered products are provided in Table 1.

Air barriers are materials that are used anywhere in a building assembly to stop the movement of air into or out of the conditioned space. Air barrier products include mechanically fastened building wraps, self-adhered membranes, fluid-applied materials, non-insulating board stock, and spray polyurethane foam. A material qualifies as an air barrier if its air permeance does not exceed 0.02 L/(s·m^2) at a pressure difference of 75 Pa (0.004 cfm/ft^2 at 1.56 lb/ft^2) when tested according to ASTM E2178.

Vapor barrier products are materials designed to block or limit water vapor transmission through building assemblies. They are installed on the warm side of the insulation to prevent condensation and moisture buildup that can lead to mold, rot, and structural damage. They also control vapor diffusion and maintain optimal indoor air quality.

Table 1. Product descriptions

Product series	Product name	Product description

Sheet-applied AIR-SHIELD	AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING https://www.wrmeadows.com/air-shield-air-vapor-barrier/	AIR-SHIELD 40 Mil is a sheet-applied air barrier with a 40mil membrane made from cross-laminated polyethylene bonded to modified asphalt. It adheres to various surfaces at temperatures as low as 40°F (4°C) and exceeds the Massachusetts Commercial Energy Code for Building Envelope Systems and meets ABAA Section 07261 standards. AIR-SHIELD THRU-WALL FLASHING is the AIR-SHIELD product cut to different roll sizes.
	AIR-SHIELD LOW TEMP https://www.wrmeadows.com/air-shield-low-temp/	AIR-SHIELD LOW TEMP is a sheet-applied air barrier designed for cold weather applications, adhering at temperatures as low as 20°F (-7°C). It features a 40mil membrane made from cross-laminated polyethylene and modified asphalt, meeting the Massachusetts Commercial Energy Code and ABAA Section 07261.
	AIR-SHIELD XLT https://www.wrmeadows.com/air-shield-xlt/	AIR-SHIELD XLT is a sheet-applied air barrier designed for extreme cold weather conditions, adhering at temperatures as low as 0°F (-18°C). It features a 40mil membrane made from cross-laminated polyethylene and modified asphalt, meeting the Massachusetts Commercial Energy Code and ABAA Section 07261.
Fluid-applied AIR-SHIELD	AIR-SHIELD LMP https://www.wrmeadows.com/air-shield-lmp-vapor-permeable-air-barrier/	AIR-SHIELD LMP is a water-based, liquid-applied air and moisture barrier that cures into a seamless, elastomeric membrane, preventing liquid water intrusion. It is compatible with various surfaces and meets ABAA requirements and ASTM E2357 and ASTM E2178 standards.
	AIR-SHIELD LSR https://www.wrmeadows.com/air-shield-lsr-air-vapor-liquid-moisture-barrier/	AIR-SHIELD LSR is an asphalt-free, single-component, synthetic rubber-based liquid-applied air barrier that forms a seamless, elastomeric membrane. It meets ASTM E 84, Class A, and exceeds ABAA air permeance requirements.
	AIR-SHIELD TMP https://www.wrmeadows.com/air-shield-tmp-liquid-membrane-thin-film-permeable-air-barrier/	AIR-SHIELD TMP is a water-based air/liquid moisture barrier that cures into a tough, seamless, elastomeric membrane, preventing liquid water intrusion. It meets ASTM E84, Class A, ASTM E2178, and ASTM E2357 standards
MEL-ROL	MEL-ROL 60 mil https://www.wrmeadows.com/mel-rol-waterproofing-membrane/	MEL-ROL 60 Mil is a roll-type waterproofing membrane with a 56mil polymeric waterproofing layer on cross-laminated polyethylene. It is suitable for plaza decks, parking decks, and structural slabs, and can be applied to concrete, masonry, wood, insulated walls, and metal. It meets A.R.E.M.A.® Specifications Chapter 29 and Waterproofing LARR Report 26022.
	MEL-ROL LOW TEMP https://www.wrmeadows.com/mel-rol-low-temp-waterproofing-membrane/	MEL-ROL LOW TEMP: A version of MEL-ROL designed for use in temperatures between 20°F (-7°C) and 60°F (16°C), with the same polymeric waterproofing layer on cross-laminated polyethylene, applicable to various surfaces and meeting A.R.E.M.A.® Specifications Chapter 29.

	MEL-ROL XLT https://www.wrmeadows.com/mel-rol-xlt-extra-low-temp-waterproofing-membrane/	MEL-ROL XLT: A version for use in temperatures as low as 0°F (-17.7°C), maintaining the same waterproofing properties and meeting A.R.E.M.A.® Specifications Chapter 29. It is suitable for plaza decks, parking decks, and structural slabs.

Visual representations of the studied products are presented in Figure 2.

Sheet-applied AIR-SHIELD	Fluid-applied AIR-SHIELD LMP	MEL-ROL
		

Figure 2. Visual representation of air and vapor barrier products included in this study

Table 2 lists the product information including the declaration name, products included in the declaration, CSI MasterFormat® classification, manufacturing location, and the type of declaration.

Table 2. Declared product information and type of declaration

Transparency Report [EPD]™ name	Included products	CSI MasterFormat®	UNCPC	Type of declaration
Sheet-applied AIR-SHIELD	AIR-SHIELD AIR-SHIELD THRU-WALL FLASHING AIR-SHIELD LOW TEMP AIR-SHIELD XLT	07 27 13	54530	Plant-specific, product-specific declaration for one manufacturer
Fluid-applied AIR-SHIELD	AIR-SHIELD LMP AIR-SHIELD LSR AIR-SHIELD TMP	07 27 26		
Sheet-applied MEL-ROL	MEL-ROL 60 Mil MEL-ROL LOW TEMP MEL-ROL XLT	07 13 26		

Table 3 summarizes the applicable product specifications for each product.

Table 3. Other product information

Product name	Product specifications
AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING	• Color: White • Thickness: 40mils (1mm) • Air Leakage (Tested per ASTM E283) <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: 0.035 Perms <0.1 Perms • Application Temperature: 40° F (4° C) Min. • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-air-vapor-barrier/
AIR-SHIELD LOW TEMP	• Color: White • Thickness: 40mils (1mm) • Air Leakage (Tested per ASTM E283) <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: 0.035 Perms <0.1 Perms • Application Temperature: 20˚ F (-7˚ C) Min • Service Temperature: -40° F to 158° F

	• For more information, including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-low-temp/
AIR-SHIELD XLT	• Color: White • Thickness: 40mils (1mm) • Air Leakage (Tested per ASTM E283) <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: 0.035 Perms <0.1 Perms • Application Temperature: 0° F (-18° C) Min • Service Temperature: -40° F to 158° F • For more information, including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-xlt/
AIR-SHIELD LMP	• Color: White • Thickness: 40mils (1mm) • Vapor density >1 • Air Leakage: ASTM E283 <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: > 16 Perms • Conforms with ASTM E84, Class A. • Passes Mold and Fungus Resistant ASTM D3273, ASTM D3274, ASTM D5590 • Passes Water Resistance (AATCC n127-2008) • For more information, including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-lmp-vapor-permeable-air-barrier/
AIR-SHIELD LSR	• Color: White • Thickness: 40mils (1mm) • Vapor density >1 • Air Leakage: ASTM E283 <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: > 16 Perms • Conforms with ASTM E84, Class A. • Passes Mold and Fungus Resistant ASTM D3273, ASTM D3274, ASTM D5590 • Passes Water Resistance (AATCC n127-2008) • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-lsr-air-vapor-liquid-moisture-barrier/
AIR-SHIELD TMP	• Color: White • Thickness: 40mils (1mm) • Vapor density >1 • Air Leakage: ASTM E283 <0.02 L/s M^2 @ 75 Pa • Water Vapor Permeance: ASTM E96: > 16 Perms • Conforms with ASTM E84, Class A. • Passes Mold and Fungus Resistant ASTM D3273, ASTM D3274, ASTM D5590 • Passes Water Resistance (AATCC n127-2008) • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/air-shield-tmp-liquid-membrane-thin-film-permeable-air-barrier/
MEL-ROL 60 Mil	• Color: Carrier Film: white; Polymeric Membrane: black • Thickness: Carrier Film: 4mils; Polymeric Membrane: 56mils • Water Vapor Permeance: ASTM E96: 0.036 Perms <0.1 Perms • Application Temperature: 40˚ F (4˚ C) Min • AATCC Test Method 127, AC212, AC38 or E2556 • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/mel-rol-waterproofing-membrane/
MEL-ROL LOW TEMP	• Color: Carrier Film: white; Polymeric Membrane: black • Thickness: Carrier Film: 4mils; Polymeric Membrane: 56mils • Water Vapor Permeance: ASTM E96: 0.036 Perms <0.1 Perms • Application Temperature: 40˚ F (4˚ C) Min • AATCC Test Method 127, AC212, AC38 or E2556 • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/mel-rol-low-temp-waterproofing-membrane/
MEL-ROL XLT	• Color: Carrier Film: white; Polymeric Membrane: black • Thickness: Carrier Film: 4mils; Polymeric Membrane: 56mils • Water Vapor Permeance: ASTM E96: 0.036 Perms <0.1 Perms • Application Temperature: 40˚ F (4˚ C) Min

	• AATCC Test Method 127, AC212, AC38 or E2556 • For more information including details about the materials that conform to the relevant standards, visit: https://www.wrmeadows.com/mel-rol-xlt-extra-low-temp-waterproofing-membrane/

2.3 Declared unit

This LCA covers the cradle-to-gate life cycle stage. According to the PCR, the declared unit is one square meter (1 m^2). For fluid-applied products, the mass of material required per declared unit is approximated by dividing the product density (kg/L) by the manufacturer's specified dry product thickness coverage rate (m^2/L), excluding waste.

The reference flow for each product is provided in Table 4. For fluid-applied AIR-SHIELD products, the product density, manufacturer-specified dry product thickness, and product percent solids are also provided. The environmental impacts for fluid-applied AIR-SHIELD products are proportional to dry product thickness. If applied for a specific application to a thickness other than as specified in the report, the results of the new thickness can be calculated proportionally to the reported results.

Table 4. Reference flow (mass per declared unit) for the studied products

Product name	Product Type	Reference flow (kg/m^2)
AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING	Sheet-applied air barrier membrane	1.328
AIR-SHIELD LOW TEMP	Sheet-applied air barrier membrane	1.328
AIR-SHIELD XLT	Sheet-applied air barrier membrane	1.328
MEL-ROL 60 Mil	Sheet-applied water resistive membranes	1.704
MEL-ROL LOW TEMP	Sheet-applied water resistive membranes	1.704
MEL-ROL XLT	Sheet-applied water resistive membranes	1.704
AIR-SHIELD LMP	Fluid-applied air barrier	**Reference flow:** 1.775 kg/m^2 **Background:** AIR-SHIELD LMP is typically applied at 55 mil wet thickness. The theoretical coverage rate (not including waste) at a thickness of 55 mils is approximately 29 ft^2/gal (0.72 m^2/L) to attain a 23 mil dry thickness. **Product density:** 10.67 lbs/gal = 1.278 kg/L **Coverage rate (kg/m^2):** (1.278 kg/L)/(0.72 m^2/L) = 1.775 kg/m^2 **% solids by weight:** 65%
AIR-SHIELD LSR	Fluid-applied air barrier	**Reference flow:** 2.085 kg/m^2 **Background:** AIR-SHIELD LSR is typically applied at 75 mil thickness wet. The theoretical coverage rate (not including waste) at a thickness of 75 mils is approximately 22 ft^2/gal (0.54 m^2/L) to attain a 40 mil dry thickness. **Product density:** 9.4 lbs/gal = 1.126 kg/L **Coverage rate (kg/m^2):** (1.126 kg/L)/(0.54 m^2/L) = 2.085 kg/m^2 **% solids by weight:** 65%
AIR-SHIELD TMP	Fluid-applied air barrier	**Reference flow:** 0.515 kg/m^2 **Background:** AIR-SHIELD TMP is typically applied at 16 mil thickness wet. The theoretical coverage rate (not including waste) at a thickness of 16 mils is approximately 100 ft^2 /gal (2.454 m^2 /L) to attain a 9 mil dry thickness on exterior gypsum sheathing. **Product density:** 10.55 lbs/gal = 1.264 kg/L **Coverage rate (kg/m^2):** (1.264 kg/L)/(2.454 m^2/L) = 0.515 kg/m^2

		% solids by weight: 65%

2.4 System boundary

This section describes the system boundary for the analysis. The system boundary defines which life cycle stages are included and which are excluded.

Scope	PRODUCTION STAGE			CONSTRUCTION STAGE		USE STAGE					END-OF-LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
	Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Deconstruction/Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste	Reuse, Recovery, Recycling Potential
						B6 Operational energy use									
						B7 Operational water use									
Cradle to gate	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Figure 3. Applied system boundary

Figure 3 illustrates all the life cycle phases included in this study. This LCA's system boundary is from cradle to gate. Therefore, the life cycle activities and related processes shall include modules A1, A2, and A3. This includes raw materials extraction and preprocessing, transportation, and manufacturing and final assembly for both the product and its associated packaging. Table 5 lists specific inclusions and exclusions for the system boundary. This study follows the modularity principle, where all environmental impacts and potential impacts are declared in the life cycle stage where they can be attributed.

Table 5. System boundary inclusions and exclusions

Included	Excluded
• Raw material extraction for components • Transport of raw materials and other inputs to the manufacturing facilities, and internal transport between facilities • Processing of raw materials into components • Packaging of raw materials and their disposal • Generation of electricity, steam, and heat from primary energy resources used in manufacturing, including their extraction, refining, and transport • Transport of components to assembly locations • Manufacturing scrap and its disposal • Packaging for the final product, including transportation and waste disposal to make product ready for shipment	• Manufacturing and maintenance of major capital equipment • Human labor and employee transport

2.4.1. Production stage (A1-A3)

The production stage starts when raw materials are extracted from nature and ends when the product is packaged and ready to be loaded onto a transport vehicle at the W. R. MEADOWS facility.

The production stage includes three product life cycle modules:

I. **Extraction and upstream preprocessing (A1)**
   - Extraction and processing of raw materials
   - Transport of raw materials from extraction/production to manufacturer
   - Energy and water consumption for raw material manufacturing
   - Raw material packaging inputs

II. **Transport to factory (A2)**
   - Transportation of components to W. R. MEADOWS's manufacturing facility

III. **Manufacturing (A3)**
   - Energy and water consumption for product manufacturing
   - Product packaging inputs
   - Releases to environmental media (air, soil, ground, & surface water)
   - Manufacturing waste transportation from plant to disposal sites
   - Manufacturing waste disposal/recycling/reuse/energy recovery
   - Final product preparation for outbound shipment

3 LIFE CYCLE INVENTORY ANALYSIS

This chapter includes an overview of the obtained data and data quality that has been used in this study. A comprehensive life cycle inventory calculation workbook, which catalogs the flows crossing the system boundary and provides the starting point for life cycle impact assessment, can be found in the appendix.

3.1 Data collection procedures

Primary data was provided by W. R. MEADOWS representing the supply chain (A1-A2) and manufacturing processes (A3) for the products for all four plants [redacted]. Data was collected in a consistent manner and level of detail to ensure high-quality data. All submitted data were checked for quality multiple times on the plausibility of inputs and outputs using mass balance and benchmarking. All questions regarding data, including gaps, outliers, and any inconsistencies, were resolved with the W. R. MEADOWS plant managers. Twelve months of data (CY2023) was collected. An analyst at Sustainable Minds developed the resulting inventory calculations and subsequently checked them internally.

Expert judgment was used in selecting appropriate data sets to model the associated activities in this study, including materials and energy, which have been noted in the following sections. Databases adopted in the model include ecoinvent v3.10 and US-EI 2.2 databases. Overall, the quality of the data used in this study is considered to be good and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness, as described below.

3.2 Primary data

Primary data were collected for every process in the product system under W. R. MEADOWS's control. If direct measurements were unavailable, primary data were collected using the W. R. MEADOWS facility representative personnel's best engineering estimates based on actual production.

3.2.1. Raw materials acquisition and transportation (A1-A2)

These modules represent raw materials extraction, preprocessing/upstream processing, and transportation to the manufacturing facility. W. R. MEADOWS provided full bills of material (BOMs) with a detailed breakdown of each product's raw material mass percentage.

Waste and scrap created during raw material upstream processing, and the emissions associated with transporting waste and scrap to the point of disposal during upstream processing, were included in the background data sets used to model those raw materials. In addition, the amount of raw materials needed to manufacture the final product was scaled up to account for production wastage. [redacted]

All hazardous materials, defined by the Resource Conservation and Recovery Act (RCRA) Subtitle C or listed by the Toxic Release Inventory (TRI), are fully included. Fluid-applied AIR-SHIELD products contain a biocide classified as hazardous and are accounted for in the modeling.

Table 6 and Table 7 present the composition of various AIR-SHIELD and MEL-ROL sheet-applied air barrier and waterproofing membranes. It shows consistent total weights (1.33 kg/m²) and (1.70 kg/m²) across all AIR-SHIELD and MEL-ROL products [redacted]. All incoming raw materials and their respective packaging methods are listed below. Materials arrive at the facility in cardboard boxes or LDPE bags and are placed on wooden pallets. All incoming packaging has been included in the modeling analysis.

Table 6. Sheet-applied AIR-SHIELD and MEL-ROL raw material composition by weight per declared unit

Raw material	AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING	AIR-SHIELD LOW TEMP	AIR-SHIELD XLT	MEL-ROL 60 Mil	MEL-ROL LOW TEMP	MEL-ROL XLT
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total (kg)	**1.33**	**1.33**	**1.33**	**1.70**	**1.70**	**1.70**

Table 7. Sheet-applied AIR-SHIELD and MEL-ROL raw material composition by percentage

Raw material	AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING	AIR-SHIELD LOW TEMP	AIR-SHIELD XLT	MEL-ROL 60 Mil	MEL-ROL LOW TEMP	MEL-ROL XLT
SBS-modified bitumen mixture	60-75%	65-80%	45-80%	65-80%	75-80%	65-80%
Limestone	5-10%	5-10%	5-10%	5-10%	5-10%	5-10%
Film	5-10%	5-10%	5-10%	5-10%	5-10%	5-10%
Packaging, wood pallet	5-10%	5-10%	5-10%	5-10%	5-10%	5-10%
Packaging, paper	5-10%	5-10%	<5%	<5%	5-10%	5-10%
Packaging, carton	<5%	<5%	<5%	<5%	<5%	<5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 8 shows the raw material composition by weight (kg/m²) for fluid-applied AIR-SHIELD products LMP, LSR, and TMP. Table 9 presents the corresponding material composition as percentages, highlighting the relative contribution of each ingredient to the total formulation. All incoming raw materials are packaged in plastic totes, steel drums, or paper bags, and the packaging materials are included in the modeling assessment.

Table 8. Fluid-applied AIR-SHIELD (LMP, LSR and TMP) raw material composition by weight per declared unit

Raw material	AIR-SHIELD LMP	AIR-SHIELD LSR	AIR-SHIELD TMP
[redacted]	[redacted]	[redacted]	[redacted]
Total (kg)	**1.77**	**2.06**	**0.515**

Table 9. Fluid-applied AIR-SHIELD (LMP, LSR and TMP) raw material composition by percentage

Raw material	AIR-SHIELD LMP	AIR-SHIELD LSR	AIR-SHIELD TMP
Polymers	35-40%	55-65%	35-40%
Mineral filler	15-20%	10-15%	15-20%
Additives	10-30%	10-30%	10-30%
Calcium carbonate	10-15%	5-10%	10-15%
Water	10-15%	5-10%	10-15%
Oils	8-10%	10-15%	8-10%

Plasticizer	3-5%	3–5%	3–5%
Pigment	<1%	<1%	<1%
Silica	0%	<1%	0%
Packaging, plastic pail	1-3%	1-3%	1-3%
Packaging, pallet	<1%	0%	<1%
Packaging, steel drum	1-3%	1-3%	1-3%
Packaging, stretch film	<1%	<1%	<1%
Total	**100%**	**100%**	**100%**

Raw materials are extracted and manufactured by material suppliers. Suppliers then transport raw materials to the W. R. MEADOWS's manufacturing plants. All ingredients sourced in North America are transported by either 24T truck & trailer or 25T truck & trailer. Materials were assumed to come directly from the supplier or through a distribution center. 90% of incoming pallets were assumed to be sold to a third party for reuse, with the remaining 10% being landfilled. Transportation modes and distances for each of the raw materials supplied are provided in Table 10.

Table 10. Raw material supplier transportation modes and distances

Raw material	Road distance (miles)	Means of transportation
[redacted]	[redacted]	Tanker truck
[redacted]	[redacted]	Semi-truck
City water	[redacted]	Utility piping
[redacted]	[redacted]	Enclosed trailer
[redacted]	[redacted]	Train

Table 11. Raw material transportation quantities per declared unit

Product	Raw material transportation (lbmi)
AIR-SHIELD LMP	[redacted]
AIR-SHIELD LMP	[redacted]
AIR-SHIELD LMP	[redacted]
AIR-SHIELD LSR	[redacted]
AIR-SHIELD LSR	[redacted]
AIR-SHIELD LSR	[redacted]
AIR-SHIELD TMP	[redacted]
AIR-SHIELD TMP	[redacted]
AIR-SHIELD TMP	[redacted]
AIR-SHIELD 40 Mil	[redacted]
AIR-SHIELD LOW TEMP	[redacted]
AIR-SHIELD XLT	[redacted]
MEL-ROL 60 Mil	[redacted]
MEL-ROL LOW TEMP	[redacted]
MEL-ROL XLT	[redacted]

3.2.2. Manufacturing (A3)

The raw material batches are transported to W. R. MEADOWS facilities and stored before processing. Manufacturing inputs and outputs are reported based on fluid-applied and sheet-applied product types. [redacted] Once mixing is complete, the product is filtered through two stages and transferred into packaging containers, including 5-gallon plastic pails and 55-gallon steel drums. Pails and drums are secured on pallets with plastic stretch wrap or strapping for shipment. Ancillary materials such as filters and pads are disposed of as process waste; however, their weights are small enough when allocated to each declared unit that they were not accounted for in the model.

Table 12 and Table 13 present the manufacturing inputs and waste outputs per declared unit for fluid-applied AIR-SHIELD products at each production site. Waste generated is primarily from incoming packaging materials, with plastic waste assumed to be landfilled in an open sanitary landfill and wood pallets considered to be reused. Waste transportation distances are calculated based on the proximity of each manufacturing facility to the nearest waste processing site.

Table 12. Fluid-applied AIR-SHIELD manufacturing inputs per declared unit per plant

Product	**Electricity (kWh)**	**Plastic pail (kg)**	**Steel drum (kg)**	**Plastic wrap (kg)**	**Wood pallet (kg)**
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 13. Fluid-applied AIR-SHIELD waste outputs per declared unit per plant

Product	**Waste paper (kg)**	**Waste plastic (kg)**	**Waste water (gal)**	**Waste transport (lbmi)**
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LMP	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LSR	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD TMP	[redacted]	[redacted]	[redacted]	[redacted]

For the production of sheet-applied AIR-SHIELD and MEL-ROL, raw materials are introduced [redacted]. Once the mix is complete, it is pumped from the mixer to a let-down (packaging) tank [redacted]. This layer is sandwiched between the base film and release paper as the substrates are pulled through the machine, completing the production process. Rolls are then packaged into cardboard boxes.

For AIRSHIELD and MEL-ROL, each sheet-applied product is rolled onto a 3-inch diameter core [redacted]. Rolled units are packaged in cardboard cartons or protective wraps, then palletized. Cartons are stacked in a stable configuration on wood pallets and secured with stretch wrap or plastic strapping for transport.

Table 14 through Table 16 show the manufacturing inputs and waste outputs per declared unit, as well as the packaging accounted for per declared unit for each sheet-applied product.

Table 14. Sheet-applied AIR-SHIELD and MEL-ROL manufacturing inputs per declared unit

Product	Electricity (kWh)	Water (gal)	Natural gas (BTU)
AIR-SHIELD 40 Mil	[redacted]	[redacted]	[redacted]
AIR-SHIELD LOW TEMP	[redacted]	[redacted]	[redacted]
AIR-SHIELD XLT	[redacted]	[redacted]	[redacted]
MEL-ROL 60 Mil	[redacted]	[redacted]	[redacted]
MEL-ROL LOW TEMP	[redacted]	[redacted]	[redacted]
MEL-ROL XLT	[redacted]	[redacted]	[redacted]

Table 15. Sheet-applied AIR-SHIELD and MEL-ROL final packaging inputs per declared unit

Product	[redacted] film (kg)	Plastic core (kg)	Zip strip (kg)	Carton (kg)	Wood pallet (kg)	Coated release paper (kg)
AIR-SHIELD 40 Mil	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD LOW TEMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AIR-SHIELD XLT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MEL-ROL 60 Mil	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MEL-ROL LOW TEMP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MEL-ROL XLT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 16. Sheet-applied AIR-SHIELD and MEL-ROL waste outputs per declared unit

Product	Waste plastic (kg)	Waste cardboard (kg)	Waste transport (lbmi)
AIR-SHIELD 40 Mil	[redacted]	[redacted]	[redacted]
AIR-SHIELD LOW TEMP	[redacted]	[redacted]	[redacted]
AIR-SHIELD XLT	[redacted]	[redacted]	[redacted]
MEL-ROL 60 Mil	[redacted]	[redacted]	[redacted]
MEL-ROL LOW TEMP	[redacted]	[redacted]	[redacted]
MEL-ROL XLT	[redacted]	[redacted]	[redacted]

Figure 4 illustrates the cradle-to-gate process flow diagram for W. R. MEADOWS fluid-applied AIR-SHIELD, sheet-applied AIR-SHIELD, and MEL-ROL. This study has included all upstream energy and material flows related to production.

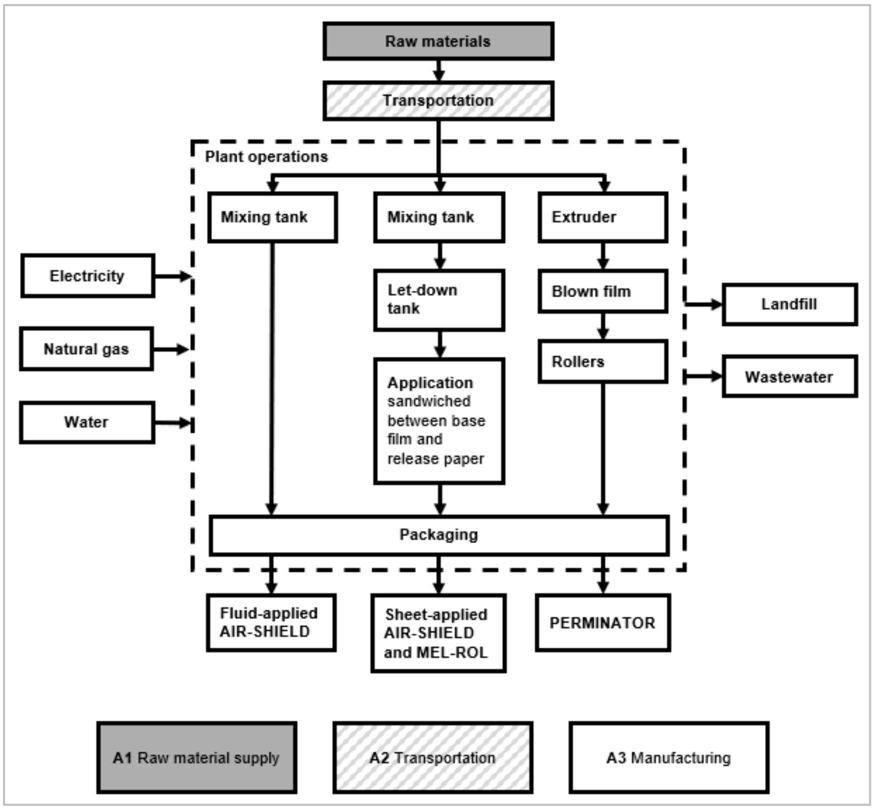

Figure 4. System boundary and product flow diagram for air and vapor barrier product manufacturing

3.2.3. Additional information for biogenic carbon disclosure

This section discloses the biogenic carbon emissions from packaging associated with the final product in the installation stage (A5). While the impacts from installation are out of the scope of this cradle-to-gate study, ISO 21930:2017 requires that biogenic carbon emissions associated with packaging disposed of after product installation are separately reported. The biogenic carbon removals from packaging in the manufacturing stage (A3) are later accounted for as biogenic carbon emissions in the installation stage (A5). The biogenic carbon emissions from packaging are detailed in Table 17.

Table 17. Biogenic carbon disclosure per declared unit

Product name	Biogenic carbon emission from packaging (A5)	Unit
AIR-SHIELD LMP	4.94E-02	kg CO_2
AIR-SHIELD LSR	3.55E-04	kg CO_2
AIR-SHIELD TMP	3.55E-04	kg CO_2
AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING	5.48E-01	kg CO_2
AIR-SHIELD LOW TEMP	6.93E-01	kg CO_2
AIR-SHIELD XLT	4.18E-01	kg CO_2
MEL-ROL 60 Mil	5.37E-01	kg CO_2
MEL-ROL LOW TEMP	7.03E-01	kg CO_2
MEL-ROL XLT	6.93E-01	kg CO_2

3.3 Background data

This section details background data sets used for modeling all relevant activities associated with the cradle-to-gate life cycle of the air and vapor barrier products. Each table lists the data set name, database, reference year, and geography. The LCA model was created using SimaPro Analyst 9.5. The ecoinvent v3.10 and US-EI 2.2 databases provided the life cycle inventory data of the raw materials and processes for modeling the products.

3.3.1. Raw materials production

Data representing upstream and downstream raw materials were included. Table 18 Lists the most relevant LCI data sets used in modeling the raw materials.

Table 18. Key material data sets used in inventory analysis

Material name	Data set	Database	Technology	Reference year	Geography
City water	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Styrene-butadiene copolymer (sheet-applied AIR-SHIELD)	*Custom data set:* [redacted] Styrene {GLO}| market for styrene | Cut-off, U; Butadiene {GLO}| market for | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Styrene-butadiene copolymer (fluid-applied AIR-SHIELD)	*Custom data set:* [redacted] Styrene {GLO}| market for styrene | Cut-off, U Butadiene {RoW}| market for butadiene | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe), Global (GLO)
Mastic asphalt	Mastic asphalt {GLO}| market for mastic asphalt | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Paraffin	Paraffin {GLO}| market for paraffin | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
[redacted] oil	Light fuel oil {RoW}| light fuel oil production, petroleum refinery operation | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Alkylbenzene	Alkylbenzene, linear {GLO}| market for alkylbenzene, linear | Cut-off, S	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Limestone	Limestone, crushed, washed {RoW}| limestone production, crushed, washed | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
[redacted] film	Polyethylene, high density, granulate {GLO}| market for polyethylene, high density, granulate | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Sanitizer	Chemical, organic {GLO}| market for chemical, organic | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Kaolin	Kaolin {RoW}| kaolin production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Acrylic emulsion	Acrylic binder, with water, in 54% solution state {RoW}| market for acrylic binder, with water, in 54% solution state | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)

Propylene glycol	Propylene glycol, liquid {RoW}| market for propylene glycol, liquid | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Calcium carbonate	Calcium carbonate, precipitated {RoW}| calcium carbonate production, precipitated | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Ethylene vinyl acetate copolymer	Ethylene vinyl acetate copolymer {RoW}| market for ethylene vinyl acetate copolymer | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Isopropanol	Isopropanol {RoW}| market for isopropanol | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Diethylene glycol	Diethylene glycol {RoW}| market for diethylene glycol | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Linear low-density polyethylene resin	Polyethylene, linear low-density, LLDPE, virgin resin, at plant	LCA Commons	Appropriate technology	2020	United States
UVI	*Custom data set:* [redacted] Succinic acid {GLO}| succinic acid production | Cut-off, U Chemical, organic {GLO}| market for chemical, organic | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Biocide	*Custom data set:* [redacted] Biocides, for paper production, unspecified, at plant/RER U City water	ecoinvent v3.10	Appropriate technology	2023	Europe (RER)
Plastic wrap	Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Plastic tote	Polyethylene, high density, granulate, recycled {US}| market for polyethylene, high density, granulate, recycled | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States
Gaylord box	Corrugated board box {US}| market for corrugated board box | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States
Liner	Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Steel drum	Steel hot dip galvanised {GLO} | blast furnace route and electric arc furnace route | production mix, at plant | 1kg, typical thickness between 0.3 - 3 mm. typical width between 600 - 2100 mm | LCI result	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Zip strip	*Custom data set:* [redacted] N,N-dimethylformamide {GLO}| market for N,N-dimethylformamide | Cut-off, U; [redacted] Propylene glycol, liquid {RoW}| market for propylene glycol, liquid | Cut-off, U; [redacted] Dimethyl carbonate {GLO}| market for dimethyl carbonate | Cut-off, U; [redacted] Non-ionic surfactant {GLO}| market for non-ionic surfactant | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Global (GLO)
Cardboard box	Corrugated board box {RoW}| market for corrugated board box | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Wood pallet	EUR-flat pallet {RoW}| EUR-flat pallet production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Packaging paper	Kraft paper {RoW}| market for kraft paper | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)

3.3.2. Transportation

Transportation distances and modes of transport were included for transporting raw materials to the manufacturing facility. The typical vehicle used for shipment is a semi-truck. As the transportation data sets represent load factors as an average of empty and fully loaded (i.e., average load factor), empty backhauls are accounted for in the model. Table 19 Shows the most relevant LCI data sets used in modeling transportation.

Table 19. Transportation data sets used in inventory analysis

Vehicle type	Data set	Database	Technology	Reference year	Geography
Train	Transport, freight train {US}| market for transport, freight train | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	United States
Flatbed and semi-truck	Transport, freight, lorry 16-32 metric ton, EURO5 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)

3.3.3. Fuels and energy

Electricity at the facility was modeled using regionally specific inventory data based on the electricity market consumption mix in the specific plant region. The grid mixes used were the most recent from eGRID for the disclosed subregions. Table 20 Shows the most relevant LCI data sets used in fuels and energy.

Table 20. Key energy data sets used in inventory analysis

Energy source	Data set	Database	Technology	Reference year
Electricity	Electricity mix, eGrid subregion, SRSO/US U	LCA Commons	Appropriate technology	2023
Electricity	Electricity mix, eGrid subregion, ERCT/US U	LCA Commons	Appropriate technology	2023
Electricity	Electricity mix, eGrid subregion, MROE/US U	LCA Commons	Appropriate technology	2023
Electricity	Electricity mix, eGrid subregion, MROW/US U	LCA Commons	Appropriate technology	2023
Natural gas	Heat, district or industrial, natural gas {RoW}| market for heat, district or industrial, natural gas | Cut-off, U	ecoinvent v3	Appropriate technology	2022
Water	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent v3	Appropriate technology	2022

3.3.4. Disposal

Disposal processes were obtained from the ecoinvent v3.10 database. These processes were selected to correspond to the disposal of fiberglass dust and packaging waste. Table 21 Lists the relevant disposal data sets used in the model.

Table 21. Key disposal data sets used in inventory analysis

Disposal activity	Data set	Database	Technology	Reference year	Geography
Landfill of scrap boards	Waste wood, untreated {RoW}| treatment of waste wood, untreated, sanitary landfill | Cut-off, U	ecoinvent v3	Appropriate technology	2023	United States
Landfill of plastic liner	Waste polyethylene {RoW}| market for waste polyethylene | Cut-off, U	ecoinvent v3	Appropriate technology	2023	United States
Landfill of solid waste	Municipal solid waste {RoW}| treatment of municipal solid waste, sanitary landfill | Cut-off, U	ecoinvent v3	Appropriate technology	2023	United States
Road transport for collecting municipal waste	Municipal waste collection service by 21 metric ton lorry {GLO}| market for municipal waste collection service by 21 metric ton lorry | Cut-off, U	ecoinvent v3	Appropriate technology	2023	United States

3.4 Cut-off criteria

The cut-off criteria on a unit process level can be summarized as follows:

- All inputs and outputs to a (unit) process shall be included in the calculation of the pre-set parameters results for which data are available. Data gaps shall be filled by conservative assumptions with average, generic, or proxy data. Any assumptions for such choices shall be documented. Assumptions and proxies, whenever used, have been explained in this report.
- Mass – If a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern. Select mass flows have been omitted in this study where they were deemed environmentally irrelevant.
- Energy – If a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern. No known energy flow has been omitted in this study.
- Environmental relevance – If a flow meets the above criteria for exclusion, yet it is thought to potentially have a significant environmental impact, it is included. A biocide, which was present at <0.001%, was included for its environmental relevance.
- Hazardous and toxic materials – The study shall include all hazardous and toxic materials in the inventory; therefore, the cutoff rules shall not apply to such substances. No substances required to be reported as hazardous are associated with the production of this product, including upstream raw material supply and raw material manufacturing.
- The sum of the neglected material flows does not exceed 5% of mass, energy, or environmental relevance for flows indirectly related to the process (e.g., operating materials).

In this report, flows of less than 1% of the cumulative mass were excluded from modeling when their environmental relevance was not a concern, and the sum of excluded mass and energy flows was below 5%; therefore, these criteria have been met. The completeness of the bill of materials defined in this report satisfies the above-defined cut-off criteria.

3.5 Allocation

Whenever a system boundary is crossed, environmental inputs and outputs must be assigned to the different products. Where multi-inputs or multi-outputs are considered, the same applies. The PCR prescribes to report where and how allocation occurs in modeling the LCA.

Each W. R. MEADOWS facility produces multiple types of products each year. To allocate electricity and natural gas consumption accurately to each product, total annual energy consumption was distributed based on the proportion of each product's annual production (by mass) relative to the total plant production. This approach assigns manufacturing activities proportionally to each product type.

The facility produces different products. Therefore, electricity, water, and natural gas inputs were allocated using annual production quantities in mass. Similarly, waste disposal outputs were allocated based on the ratio of total plant production to each product's production and then normalized to functional unit mass. There are no co-products produced during their manufacturing processes. Useable output flows such as scrap are not considered co-products but are considered waste, and no allocation to secondary material, secondary fuels, or recovered energy was applied.

The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring. The allocation procedures used in background data sets were accepted without modification.

3.6 Discussion of data quality

Inventory data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data, in combination with consistent background LCA information from the ecoinvent v3.10 and US-EI 2.2 databases, were used.

Precision and completeness

- *Precision:* As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Background data are from the ecoinvent v3.10 and US-EI 2.2 databases with documented precision to the extent available.

- *Completeness:* Sustainable Minds worked with each plant manager to obtain a comprehensive set of primary data associated with the manufacturing processes. The product system was checked for mass balance and completeness of the inventory. The data set was considered complete based on our understanding of the manufacturing site and a review with key stakeholders on the W. R. MEADOWS team, and cut-off criteria were observed consistent with those prescribed in the PCR. Besides capital equipment, no data was knowingly omitted.

Consistency and reproducibility

- *Consistency*: Primary data were collected with a similar level of detail, while background data were sourced primarily from the ecoinvent database. Other databases were used if data were not available in ecoinvent or the data set was judged to be more representative. Other methodological choices were made consistently throughout the model.
- *Reproducibility*: Reproducibility is warranted as much as possible through the disclosure of input-output data, data set choices, and modeling approaches in this report. Based on this information, a knowledgeable third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

- *Temporal:* All primary data were collected for CY2023, ensuring the representativeness of the manufacturing process. Secondary data were obtained from the ecoinvent v3.10 and US-EI 2.2 databases and are typically representative of the recent years.

- *Geographical:* The geographical coverage for this study is based on United States system boundaries for all processes and products. Whenever US background data was not readily available, rest of world (non-Europe) data or global data were used. Input and output data for modeling come from the manufacturing facility which is responsible for production.

- *Technological*: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be high.

3.7 Comparability

ISO 21930:2017 section 5.5 highlights the following limitations and clarifications in EPD comparability: EPDs are comparable only if they use the same PCR (or sub-category PCR where applicable), include all relevant information modules, and are based on equivalent scenarios with respect to the context of construction works.

EPDs can only be compared when the same functional requirements between products are ensured, and the requirements of ISO 21930:2017 section 5.5 are met. However, variations and deviations are possible. For example, different LCA software and background LCI data sets may lead to different results for the life cycle stages declared.

3.8 Assumptions and limitations

A life cycle assessment of a product system is broad and complex, and it inherently requires assumptions and simplifications. The following limitations of the study should be recognized:

- Primary data were modeled based on the information provided by W. R. MEADOWS and supplemented by data contained in the technical and safety data sheets provided. Proxy materials were used when matching secondary data sets were not identified.
- Since energy inputs were not available per product, electricity and natural gas consumption were allocated proportionately based on the annual square foot production percentage for individual panel products versus total site production.
- Generic data sets used for material inputs, transport, and waste processing are considered good quality, but actual impacts from material suppliers, transport carriers, and local waste processing may vary.
- The impact assessment methodology categories do not represent all possible environmental impact categories.
- Characterization factors used within the impact assessment methodology may contain varying levels of uncertainty.
- LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.
- No "green power" is used in this LCA.
- No renewable certificates or purchased CO_2 offsets are included in the LCA.

4 Impact Assessment Methods

4.1 Impact assessment characterization

The environmental indicators as required by the PCR are included as well as other indicators required to use the SM2013 Methodology [5] (see Table 22). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [6]. Long-term emissions (>100 years) are not taken into consideration in the impact estimate. USEtox indicators[2] are used to evaluate toxicity. Emissions from waste disposal are considered part of the product system under study, according to the "polluter pays principle".

Table 22. Selected impact categories and units

Impact category	Unit	Description
Acidification	kg SO_2 eq (sulphur dioxide)	Acidification processes increase the acidity of water and soil systems and causes damage to lakes, streams, rivers and various plants and animals as well as building materials, paints and other human-built structures.
Ecotoxicity	CTUe	Ecotoxicity causes negative impacts to ecological receptors and, indirectly, to human receptors through the impacts to the ecosystem.
Eutrophication	kg N eq (nitrogen)	Eutrophication is the enrichment of an aquatic ecosystem with nutrients (nitrates and phosphates) that accelerate biological productivity (growth of algae and weeds) and an undesirable accumulation of algal biomass.
Global warming	kg CO_2 eq (carbon dioxide)	Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere.
Ozone depletion	kg CFC-11 eq	Ozone depletion is the reduction of ozone in the stratosphere caused by the release of ozone depleting chemicals.
Carcinogenics	CTUh	Carcinogens have the potential to form cancers in humans.
Non-carcinogenics	CTUh	Non-Carcinogens have the potential to causes non-cancerous adverse impacts to human health.
Respiratory effects	kg $PM_{2.5}$ eq (fine particulates)	Particulate matter concentrations have a strong influence on chronic and acute respiratory symptoms and mortality rates.
Smog	kg O_3 eq (ozone)	Smog formation (photochemical oxidant formation) is the formation of ozone molecules in the troposphere by complex chemical reactions.
Fossil fuel depletion	MJ surplus	Fossil fuel depletion is the surplus energy to extract minerals and fossil fuels.

With respect to global warming potential, biogenic carbon uptake and removal are included in impact category calculations. The biogenic carbon measured in this study originates from packaging materials. Greenhouse gas emissions from land-use change are expected to be insignificant and were not reported. Carbon emissions during carbonation and calcination were also considered in this study, and no carbonation or calcination are expected to occur.

[1]The 100-year period relates to the period in which the environmental impacts are modeled. This is different from the period of the declared unit. The two periods are related as follows: all environmental impacts that are created in the period of the declared unit are modeled through life cycle impact assessment using a 100-year time horizon to understand the impacts that take place.
[2] USEtox is available in TRACI and at http://www.usetox.org/

No delayed emissions from a temporary carbon sequestration are expected to occur. It shall be noted that the above impact categories represent impact potentials. They are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach).

The results from the impact assessment indicate potential environmental effects and do not predict actual impacts on category endpoints, the exceedance of thresholds, or safety margins or risks.

4.2 Normalization and weighting

To arrive at a single score indicator, normalization [7] and weighting [8] as shown in Table 23 conforming to the SM2013 Methodology were applied. The SM2013 Methodology uses TRACI 2.1 impact categories developed by the U.S. EPA, and North American normalization and weighting values developed by the EPA and NIST, respectively, to calculate single-figure LCA results Sustainable Minds recognizes that weighting is socially defined based on the importance that society attaches to the different environmental impact categories. However, these single score indicators serve as an easy starting point to get to know the product under consideration across all impact categories, rather than focusing all efforts on just one impact category (like global warming potential). The interpretation of the results starts with the Sustainable Minds single score results and then allows users to further explore the underlying impact categories individually. Details including the characterization models, factors, and methods used, including all assumptions and limitations, can be found in the SM2013 Methodology Report [5].

Table 23. Normalization and weighting factors

Impact category	Normalization	Weighting (%)
Acidification	90.9	3.6
Ecotoxicity	11000	8.4
Eutrophication	21.6	7.2
Global warming	24200	34.9
Ozone depletion	0.161	2.4
Carcinogenics	5.07E-05	9.6
Non-carcinogenics	1.05E-03	6.0
Respiratory effects	24.3	10.8
Smog	1390	4.8
Fossil fuel depletion	17300	12.1

5 ASSESSMENT AND INTERPRETATION

This chapter includes the results from the LCA for the products studied. It details the results per declared unit, outlines the sensitivity analysis, and concludes with recommendations.

5.1 Data quality assessment

The quality of inventory data is evaluated based on its precision, completeness, consistency, and representativeness. The data used in this study is regarded as reliable and representative of the described systems, as well as their geographical, temporal, and technological contexts. When direct measurements were unavailable, the best engineering estimates based on actual production were applied. Every effort was made to ensure the highest data quality.

5.2 Resource use and waste flows

Resource use indicators, output flows and waste category indicators, and carbon emissions and removals are presented in this section. These life cycle inventory (LCI) indicators reflect the flows from and to nature for the product system prior to characterization using an impact assessment methodology to calculate life cycle impact assessment (LCIA) results (as shown in section 5.3).

LCI flows were calculated with the help of the American Center for Life Cycle Assessment's (ACLCA) guidance to the ISO 21930:2017 metrics [9]. The consumption of freshwater indicator, which was calculated in accordance with this guidance, is reported in compliance with ISO 14046. The use of renewable and non-renewable energy resources with energy content was calculated using the Cumulative Energy Demand (LHV) impact assessment methodology [10]. Abiotic depletion potential was calculated using the CML impact assessment methodology [11]. LCI flows were reported in conformance to ISO 21930:2017.

Resource use indicators represent the amount of materials consumed to produce not only the product itself but also the raw materials, electricity, natural gas, etc., that go into the product's life cycle.

Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process and is expressed in energy demand from renewable and non-renewable resources. Efficiencies in energy conversion are considered when calculating primary energy demand from process energy consumption. Water use represents the total water used over the entire life cycle. No renewable energy was used in production beyond that accounted for in the selected eGRID data sets for each subregion, and no energy was recovered.

Non-hazardous waste is calculated based on the amount of waste generated during manufacturing based on W. R. MEADOWS's record. All waste treatments in models were considered based on the local waste management code and the assumptions prescribed by the PCR. Waste treatments included within the system boundary are reported. Unrecyclable waste is disposed of in landfills.

Resource use, output flows, waste categories, and carbon emissions & removals for the studied products have been tabulated in the sections below.

5.2.1. AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING

Table 24. Resource use and waste flows for AIR-SHIELD 40 Mil in Hampshire, IL, per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	7.50E+00	2.28E-03	5.82E+00	**1.33E+01**
Renewable primary resources with energy content used as material	MJ, NCV	4.48E+00	0	0	**4.48E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.20E+01	2.28E-03	5.82E+00	**1.78E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.22E+01	1.49E+00	2.56E+00	**1.62E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.55E+01	0	0	**2.55E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	3.77E+01	1.49E+00	2.56E+00	**4.17E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	2.40E+00	1.11E-02	5.87E-01	**2.99E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	3.46E+01	1.40E+00	2.17E+00	**3.82E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	2.33E-02	3.25E-04	1.02E-02	**3.38E-02**
Non-hazardous waste disposed	kg	1.50E+00	1.29E-03	6.43E-02	**1.57E+00**
High-level radioactive waste, conditioned, to final repository	kg	9.19E-07	0	4.53E-06	**5.45E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.12E-06	7.08E-08	1.11E-05	**1.33E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.39E-02	0	-5.48E-01	**-5.61E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.39E-02	**1.39E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.2. AIR-SHIELD LOW TEMP (Hampshire, IL)

Table 25. Resource use and waste flows for AIR-SHIELD LOW TEMP in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.02E+01	3.01E-03	7.44E+00	**1.76E+01**
Renewable primary resources with energy content used as material	MJ, NCV	5.67E+00	0	0	**5.67E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.58E+01	3.01E-03	7.44E+00	**2.33E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	3.33E+01	1.96E+00	3.25E+00	**3.86E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.84E+01	0	0	**2.84E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	6.17E+01	1.96E+00	3.25E+00	**6.69E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	2.67E+00	1.14E-02	6.15E-01	**3.30E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	5.68E+01	1.84E+00	2.76E+00	**6.14E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	3.85E-02	4.29E-04	1.30E-02	**5.19E-02**
Non-hazardous waste disposed	kg	1.80E+00	1.70E-03	8.30E-02	**1.88E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.41E-06	0	5.51E-06	**6.92E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.25E-06	9.33E-08	1.35E-05	**1.68E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.80E-02	0	-6.93E-01	**-7.11E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.80E-02	**1.80E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.3. AIR-SHIELD XLT (Hampshire, IL)

Table 26. Resource use and waste flows for AIR-SHIELD XLT in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	7.64E+00	2.24E-03	3.30E+01	**4.06E+01**
≈Renewable primary resources with energy content used as material	MJ, NCV	3.42E+00	0	0	**3.42E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.11E+01	2.24E-03	3.30E+01	**4.41E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	2.32E+01	1.42E+00	1.75E+01	**4.22E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.08E+01	0	0	**2.08E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	4.41E+01	1.42E+00	1.75E+01	**6.30E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	3.32E+00	1.21E-02	6.18E-01	**3.95E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	7.32E-01	3.21E-03	2.29E-01	**9.63E-01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	3.33E-02	3.49E-04	1.04E-02	**4.40E-02**
Non-hazardous waste disposed	kg	1.62E+00	1.38E-03	7.21E-02	**1.69E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.21E-06	0	2.88E-06	**4.10E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.80E-06	7.59E-08	7.64E-06	**1.05E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.52E-02	0	-4.18E-01	**-4.34E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.52E-02	**1.52E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.4. AIR-SHIELD LMP (Cartersville, GA; Fort Worth, TX; Hampshire IL)

Table 27. Resource use and waste flows for AIR-SHIELD LMP in Cartersville, GA per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.42E+00	2.39E-03	1.71E+01	**1.85E+01**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.46E+00	2.39E-03	1.71E+01	**1.85E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	6.96E+01	1.56E+00	1.06E+01	**8.17E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	8.69E+01	1.56E+00	1.06E+01	**9.90E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	4.43E+00	7.65E-03	7.42E-01	**5.18E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	7.94E+01	1.47E+00	9.31E+00	**9.01E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.54E-02	3.31E-04	1.10E-02	**6.68E-02**
Non-hazardous waste disposed	kg	1.35E-03	1.34E-06	1.08E-03	**2.43E-03**
High-level radioactive waste, conditioned, to final repository	kg	6.78E-06	1.75E-08	9.53E-07	**7.76E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.55E-05	3.43E-08	5.11E-06	**2.07E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.20E-04	0	-4.94E-02	**-4.95E-02**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.20E-04	**1.20E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 28. Resource use and waste flows for AIR-SHIELD LMP in Fort Worth, TX per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.38E+00	4.18E-03	1.71E+01	**1.85E+01**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.42E+00	4.18E-03	1.71E+01	**1.85E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	6.96E+01	2.73E+00	1.02E+01	**8.25E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	8.69E+01	2.73E+00	1.02E+01	**9.98E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	4.43E+00	1.34E-02	6.20E-01	**5.06E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	7.94E+01	2.56E+00	9.16E+00	**9.11E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.54E-02	5.79E-04	1.10E-02	**6.70E-02**
Non-hazardous waste disposed	kg	1.35E-03	2.34E-06	1.07E-03	**2.42E-03**
High-level radioactive waste, conditioned, to final repository	kg	6.80E-06	3.06E-08	9.54E-07	**7.78E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.61E-05	5.99E-08	3.43E-06	**1.96E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.20E-04	0	-4.94E-02	**-4.95E-02**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.20E-04	**1.20E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 29. Resource use and waste flows for AIR-SHIELD LMP in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.38E+00	5.25E-03	1.71E+01	**1.84E+01**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.42E+00	5.25E-03	1.71E+01	**1.85E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	6.96E+01	3.43E+00	1.11E+01	**8.41E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	8.69E+01	3.43E+00	1.11E+01	**1.01E+02**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	4.43E+00	1.68E-02	6.75E-01	**5.12E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	7.94E+01	3.22E+00	9.55E+00	**9.21E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.54E-02	7.27E-04	1.10E-02	**6.72E-02**
Non-hazardous waste disposed	kg	1.13E-01	0	8.05E-01	**9.19E-01**
High-level radioactive waste, conditioned, to final repository	kg	6.80E-06	3.84E-08	9.54E-07	**7.79E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.61E-05	7.52E-08	8.11E-06	**2.42E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.20E-04	0	-4.94E-02	**-4.95E-02**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.20E-04	**1.20E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.5. AIR-SHIELD LSR (Cartersville, GA; Fort Worth, TX; Hampshire IL)

Table 30. Resource use and waste flows for AIR-SHIELD LSR in Cartersville, GA per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.63E+00	2.81E-03	4.80E-01	**2.12E+00**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.68E+00	2.81E-03	4.80E-01	**2.17E+00**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.42E+02	1.83E+00	8.14E+00	**1.52E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.59E+02	1.83E+00	8.14E+00	**1.69E+02**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	6.12E+00	8.98E-03	4.47E-01	**6.57E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	1.46E+02	1.72E+00	6.90E+00	**1.55E+02**
Output flows and waste category indicators					
Hazardous waste disposed	kg	6.96E-02	1.09E-03	1.58E-03	**7.23E-02**
Non-hazardous waste disposed	kg	2.21E+00	4.40E-03	6.40E-01	**2.86E+00**
High-level radioactive waste, conditioned, to final repository	kg	9.06E-06	2.05E-08	7.58E-07	**9.84E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.07E-05	3.99E-08	6.45E-06	**2.72E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-5.72E-04	0	-3.55E-04	**-9.27E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	5.72E-04	**5.72E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 31. Resource use and waste flows for AIR-SHIELD LSR in Fort Worth, TX per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.64E+00	1.29E-02	5.22E-01	**2.18E+00**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.68E+00	1.29E-02	5.22E-01	**2.22E+00**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.42E+02	8.40E+00	7.85E+00	**1.58E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.59E+02	8.40E+00	7.85E+00	**1.76E+02**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	6.12E+00	4.12E-02	2.90E-01	**6.45E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	1.46E+02	7.89E+00	6.82E+00	**1.61E+02**
Output flows and waste category indicators					
Hazardous waste disposed	kg	6.96E-02	1.78E-03	1.58E-03	**7.30E-02**
Non-hazardous waste disposed	kg	2.21E-03	7.22E-06	6.74E-04	**2.89E-03**
High-level radioactive waste, conditioned, to final repository	kg	9.06E-06	9.42E-08	7.58E-07	**9.91E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.07E-05	1.83E-07	4.52E-06	**2.54E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-5.72E-04	0	-3.55E-04	**-9.27E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	5.72E-04	**5.72E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 32. Resource use and waste flows for AIR-SHIELD LSR in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.64E+00	7.85E-03	5.22E-01	**2.17E+00**
Renewable primary resources with energy content used as material	MJ, NCV	4.08E-02	0	0	**4.08E-02**
Total use of renewable primary resources with energy content	MJ, NCV	1.68E+00	7.85E-03	5.22E-01	**2.21E+00**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.42E+02	5.13E+00	7.85E+00	**1.55E+02**
Non-renewable primary resources with energy content used as material	MJ, NCV	1.73E+01	0	0	**1.73E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.59E+02	5.13E+00	7.85E+00	**1.72E+02**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	6.12E+00	2.51E-02	2.90E-01	**6.43E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	1.46E+02	4.81E+00	6.82E+00	**1.58E+02**
Output flows and waste category indicators					
Hazardous waste disposed	kg	6.19E+01	1.61E+00	2.57E-01	**6.38E+01**
Non-hazardous waste disposed	kg	4.27E-15	0	1.28E+00	**1.28E+00**
High-level radioactive waste, conditioned, to final repository	kg	9.06E-06	5.75E-08	7.58E-07	**9.88E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.07E-05	1.12E-07	4.52E-06	**2.53E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-5.72E-04	0	-3.55E-04	**-9.27E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	5.72E-04	**5.72E-04**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.6. AIR-SHIELD TMP (Cartersville, GA; Fort Worth, TX; Hampshire IL)

Table 33. Resource use and waste flows for AIR-SHIELD TMP in Cartersville, GA per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	3.48E-01	6.48E-04	1.97E-01	**5.46E-01**
Renewable primary resources with energy content used as material	MJ, NCV	0	0	0	**0**
Total use of renewable primary resources with energy content	MJ, NCV	3.48E-01	6.48E-04	1.97E-01	**5.46E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.89E+01	4.23E-01	1.76E+00	**2.11E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	4.92E+00	0	0	**4.92E+00**
Total use of non-renewable primary resources with energy content	MJ, NCV	2.38E+01	4.23E-01	1.76E+00	**2.60E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	1.89E+00	3.08E-03	1.04E-01	**2.00E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	2.18E+01	3.98E-01	1.49E+00	**2.36E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	8.34E+00	1.33E-01	6.63E-02	**8.54E+00**
Non-hazardous waste disposed	kg	2.27E-13	0	3.10E+02	**3.10E+02**
High-level radioactive waste, conditioned, to final repository	kg	1.90E-06	4.74E-09	1.57E-07	**2.06E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.31E-06	9.21E-09	1.61E-06	**5.94E-06**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	-3.55E-04	**-3.55E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 34. Resource use and waste flows for AIR-SHIELD TMP in Fort Worth, TX per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	3.48E-01	1.18E-03	2.07E-01	**5.56E-01**
Renewable primary resources with energy content used as material	MJ, NCV	0	0	0	**0**
Total use of renewable primary resources with energy content	MJ, NCV	3.48E-01	1.18E-03	2.07E-01	**5.56E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.89E+01	7.69E-01	1.70E+00	**2.14E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	4.92E+00	0	0	**4.92E+00**
Total use of non-renewable primary resources with energy content	MJ, NCV	2.38E+01	7.69E-01	1.70E+00	**2.63E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	1.89E+00	5.59E-03	6.94E-02	**1.97E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	2.18E+01	7.22E-01	1.48E+00	**2.40E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	8.34E+00	2.42E-01	6.64E-02	**8.65E+00**
Non-hazardous waste disposed	kg	2.27E-13	0	2.86E+02	**2.86E+02**
High-level radioactive waste, conditioned, to final repository	kg	1.90E-06	8.62E-09	1.57E-07	**2.06E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.31E-06	1.67E-08	9.59E-07	**5.29E-06**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	-3.55E-04	**-3.55E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

Table 35. Resource use and waste flows for AIR-SHIELD TMP in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	3.48E-01	1.71E-03	1.87E-01	**5.36E-01**
Renewable primary resources with energy content used as material	MJ, NCV	0	0	0	**0**
Total use of renewable primary resources with energy content	MJ, NCV	3.48E-01	1.71E-03	1.87E-01	**5.36E-01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.89E+01	1.11E+00	1.80E+00	**2.18E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	4.92E+00	0	0	**4.92E+00**
Total use of non-renewable primary resources with energy content	MJ, NCV	2.38E+01	1.11E+00	1.80E+00	**2.67E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	1.89E+00	8.10E-03	7.99E-02	**1.98E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	2.18E+01	1.05E+00	1.49E+00	**2.43E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	8.34E+00	3.50E-01	6.67E-02	**8.76E+00**
Non-hazardous waste disposed	kg	2.27E-13	0	1.71E+02	**1.71E+02**
High-level radioactive waste, conditioned, to final repository	kg	1.90E-06	1.25E-08	1.57E-07	**2.07E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	4.31E-06	2.42E-08	1.80E-06	**6.13E-06**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	-3.55E-04	**-3.55E-04**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.7. MEL-ROL 60 Mil (Hampshire, IL)

Table 36. Resource use and waste flows for MEL-ROL 60 Mil in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	8.24E+00	2.32E-03	7.77E+00	**1.60E+01**
Renewable primary resources with energy content used as material	MJ, NCV	4.39E+00	0	0	**4.39E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.26E+01	2.32E-03	7.77E+00	**2.04E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.46E+01	1.47E+00	3.55E+00	**1.97E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	3.20E+01	0	0	**3.20E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	4.66E+01	1.47E+00	3.55E+00	**5.16E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	2.92E+00	6.45E-03	7.92E-01	**3.71E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	4.28E+01	1.38E+00	3.01E+00	**4.72E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	2.83E-02	0	1.33E-02	**4.16E-02**
Non-hazardous waste disposed	kg	1.75E+00	0	8.72E-02	**1.84E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.13E-06	0	3.55E-06	**4.68E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.62E-06	7.87E-08	9.40E-06	**1.21E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.75E+00	0	-5.37E-01	**-2.29E+00**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.75E+00	**1.75E+00**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.8. MEL-ROL LOW TEMP (Hampshire, IL)

Table 37. Resource use and waste flows for MEL-ROL LOW TEMP in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.03E+01	2.79E-03	7.46E+00	**1.78E+01**
Renewable primary resources with energy content used as material	MJ, NCV	5.75E+00	0	0	**5.75E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.61E+01	2.79E-03	7.46E+00	**2.35E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	3.31E+01	1.77E+00	3.42E+00	**3.83E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.87E+01	0	0	**2.87E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	6.17E+01	1.77E+00	3.42E+00	**6.69E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	2.67E+00	7.75E-03	6.16E-01	**3.30E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	5.68E+01	1.66E+00	2.91E+00	**6.14E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	3.85E-02	0	1.30E-02	**5.16E-02**
Non-hazardous waste disposed	kg	1.80E+00	0	7.88E-02	**1.88E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.41E-06	0	5.66E-06	**7.07E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.26E-06	9.45E-08	1.38E-05	**1.72E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.89E-02	0	-7.03E-01	**-7.22E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.89E-02	**1.89E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.2.9. MEL-ROL XLT (Hampshire, IL)

Table 38. Resource use and waste flows for MEL-ROL XLT in Hampshire, IL per declared unit

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	1.08E+01	3.01E-03	7.44E+00	**1.83E+01**
Renewable primary resources with energy content used as material	MJ, NCV	5.67E+00	0	0	**5.67E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.65E+01	3.01E-03	7.44E+00	**2.39E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	4.18E+01	1.92E+00	3.39E+00	**4.71E+01**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.58E+01	0	0	**2.58E+01**
Total use of non-renewable primary resources with energy content	MJ, NCV	6.76E+01	1.92E+00	3.39E+00	**7.29E+01**
Secondary materials	kg	0	0	0	**0**
Renewable secondary fuels	MJ, NCV	0	0	0	**0**
Non-renewable secondary fuels	MJ, NCV	0	0	0	**0**
Recovered energy	MJ, NCV	0	0	0	**0**
Use of net freshwater resources	m3	2.89E+00	8.38E-03	6.13E-01	**3.51E+00**
Abiotic depletion (fossil fuels)	MJ, LHV	6.22E+01	1.79E+00	2.89E+00	**6.69E+01**
Output flows and waste category indicators					
Hazardous waste disposed	kg	4.19E-02	0	1.30E-02	**5.49E-02**
Non-hazardous waste disposed	kg	1.83E+00	0	7.83E-02	**1.90E+00**
High-level radioactive waste, conditioned, to final repository	kg	1.58E-06	0	5.56E-06	**7.14E-06**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	3.64E-06	1.02E-07	1.36E-05	**1.73E-05**
Components for re-use	kg	0	0	0	**0**
Materials for recycling	kg	0	0	0	**0**
Materials for energy recovery	kg	0	0	0	**0**
Exported energy	MJ	0	0	0	**0**
Carbon emissions and removals					
Biogenic Carbon Removal from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	-1.86E-02	0	-6.93E-01	**-7.11E-01**
Biogenic Carbon Emission from Packaging	kg CO_2	0	0	1.86E-02	**1.86E-02**
Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	kg CO_2	0	0	0	**0**
Calcination Carbon Emissions	kg CO_2	0	0	0	**0**
Carbonation Carbon Removals	kg CO_2	0	0	0	**0**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	kg CO_2	0	0	0	**0**

5.3 Life cycle impact assessment (LCIA)

It shall be reiterated at this point that the reported impact categories represent impact potentials; they are approximations of environmental impacts that could occur if the emitted molecules follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are shown for the fluid-applied AIR-SHIELD products, sheet-applied AIR-SHIELD products, and MEL-ROL. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as "Global Warming Potential".

The impact assessment results are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM2013 Methodology is also applied to come up with single score results for the sole purpose of representing total impacts per life cycle phase to explain where in the product life cycle greatest impacts are occurring and what is contributing to the impacts.

These six TRACI 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. All impact categories from TRACI are used to calculate single score millipoints using the SM2013 Methodology, but it should be noted that there are known limitations related to these impact categories due to their high degree of uncertainty.

It is important to note that the LCIA indicators for carcinogenics, non carcinogenics (CTUh), and ecotoxicity (CTUe) are subject to significant uncertainty. EN 15804 includes the following disclaimer: *"The results of this environmental impact indicator shall be used with care, as the uncertainties associated with these results are high, or there is limited experience with the indicator."*

5.3.1. AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING

Table 39 shows the LCIA results, and Table 40 and Figure 5 show the percent contribution of each stage of the production of AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING. The raw material acquisition stage dominates the results for most impact categories (9 out of 10), followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING production is 1.50 kg CO_2-eq. Raw material supply contributes 1.21 kg CO_2-eq, accounting for 80.4% of the total results. The manufacturing stage was dominant for the non-carcinogenics impact category, contributing 46.9% of those results. However, the raw material acquisition stage has a larger contribution than the manufacturing stage for most impact categories including most notably ozone depletion (97.39%), fossil fuel depletion (91.53%), and ecotoxicity (83.34%). Transportation accounts for the least of the impacts among all impact categories.

Table 39. Life cycle impact assessment results for AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	1.22E+00	1.05E-01	1.98E-01	**1.52E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.39E-02	0	1.39E-02	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	1.23E+00	1.05E-01	1.84E-01	**1.52E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	1.19E+00	1.04E-01	2.04E-01	**1.50E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.39E-02	0	1.39E-02	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	1.21E+00	1.04E-01	1.90E-01	**1.50E+00**
Ozone depletion	kg CFC-11 eq	3.39E-07	1.49E-09	7.59E-09	**3.48E-07**
Acidification	kg SO_2 eq	4.62E-03	2.56E-04	9.52E-04	**5.83E-03**
Eutrophication	kg N eq	8.34E-04	1.74E-05	3.31E-04	**1.18E-03**
Smog	kg O_3 eq	6.24E-02	6.58E-03	1.62E-02	**8.52E-02**
Fossil fuel depletion	MJ surplus	4.54E+00	1.98E-01	2.22E-01	**4.96E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	7.35E-04	3.53E-05	1.78E-04	**9.48E-04**
Carcinogenics	CTUh	71.69%	1.02%	27.29%	**100%**
Non carcinogenics	CTUh	44.79%	8.36%	46.86%	**100%**
Ecotoxicity	CTUe	83.34%	8.72%	7.95%	**100%**

Table 40. Percent contributions of each stage to each impact category for AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	80.11%	6.89%	13.00%	**100%**
GWP, $TRACI_{2.1}$	80.40%	6.92%	12.68%	**100%**
Ozone depletion	97.39%	0.43%	2.18%	**100%**
Acidification	79.27%	4.40%	16.33%	**100%**
Eutrophication	70.53%	1.47%	28.00%	**100%**
Smog	73.25%	7.73%	19.02%	**100%**
Fossil fuel depletion	91.53%	3.99%	4.48%	**100%**
Additional environmental information				
Respiratory effects	77.53%	3.72%	18.75%	**100%**
Carcinogenics	71.69%	1.02%	27.29%	**100%**
Non-carcinogenics	44.79%	8.36%	46.86%	**100%**
Ecotoxicity	83.34%	8.72%	7.95%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 41). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 80.0% of the total impacts, manufacturing for 14.4%, and transportation for 5.5%.

Table 41. SM millipoint scores for AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	9.11E-02	6.28E-03	1.64E-02	**1.14E-01**

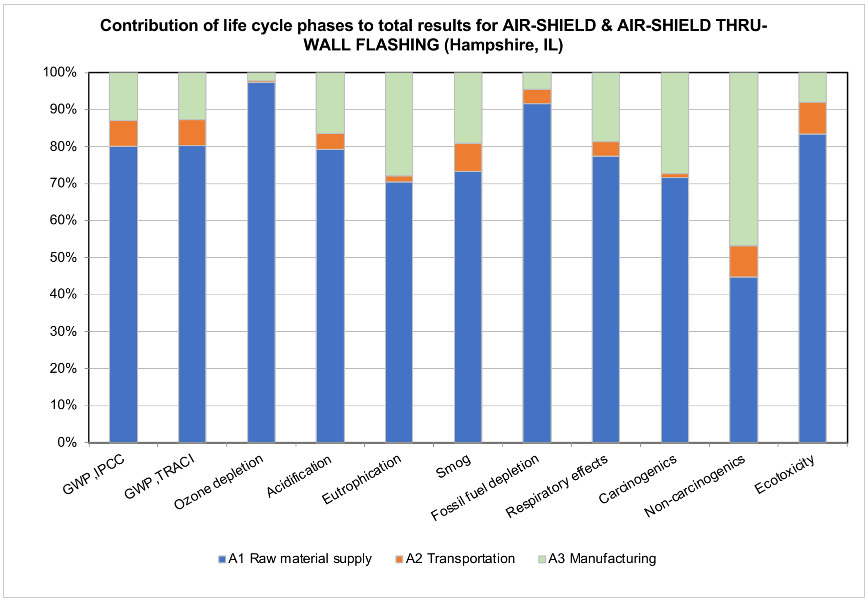

Figure 5. Contribution analysis of each impact category for AIR-SHIELD & AIR-SHIELD THRU-WALL FLASHING

5.3.2. AIR-SHIELD LOW TEMP (Hampshire, IL)

Table 42 shows the results, and Table 43 and Figure 6 show the percent contribution of each stage of the production of AIR-SHIELD LOW TEMP. The raw material acquisition stage dominates the results for all impact categories, followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD LOW-TEMP production is 2.32 kg CO_2-eq. Raw material supply contributes 1.94 kg CO_2-eq, accounting for 83.6% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and ecotoxicity were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 10.5% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

Table 42. Life cycle impact assessment results for AIR-SHIELD LOW TEMP per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	1.97E+00	1.38E-01	2.52E-01	**2.36E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.80E-02	0	1.80E-02	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	1.98E+00	1.38E-01	2.34E-01	**2.36E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	1.92E+00	1.37E-01	2.60E-01	**2.32E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.80E-02	0	1.80E-02	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	1.94E+00	1.37E-01	2.42E-01	**2.32E+00**
Ozone depletion	kg CFC-11 eq	3.58E-07	1.97E-09	9.62E-09	**3.69E-07**
Acidification	kg SO_2 eq	7.58E-03	3.38E-04	1.21E-03	**9.13E-03**
Eutrophication	kg N eq	1.61E-03	2.30E-05	4.22E-04	**2.06E-03**
Smog	kg O_3 eq	1.00E-01	8.67E-03	2.07E-02	**1.30E-01**
Fossil fuel depletion	MJ surplus	7.46E+00	2.61E-01	2.81E-01	**8.00E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.16E-03	4.65E-05	2.27E-04	**1.44E-03**
Carcinogenics	CTUh	77.89%	0.82%	21.29%	**100%**
Non carcinogenics	CTUh	51.84%	7.53%	40.63%	**100%**
Ecotoxicity	CTUe	87.85%	6.41%	5.75%	**100%**

Table 43. Percent contributions of each stage to each impact category for AIR-SHIELD LOW TEMP

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	83.41%	5.87%	10.71%	**100%**
GWP, $TRACI_{2.1}$	83.64%	5.90%	10.45%	**100%**
Ozone depletion	96.86%	0.53%	2.60%	**100%**
Acidification	83.00%	3.70%	13.30%	**100%**
Eutrophication	78.36%	1.12%	20.52%	**100%**
Smog	77.36%	6.69%	15.94%	**100%**
Fossil fuel depletion	93.22%	3.26%	3.52%	**100%**
Additional environmental information				
Respiratory effects	80.98%	3.24%	15.78%	**100%**
Carcinogenics	77.89%	0.82%	21.29%	**100%**
Non-carcinogenics	51.84%	7.53%	40.63%	**100%**
Ecotoxicity	87.85%	6.41%	5.75%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 44). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 84.2% of the total impacts, manufacturing for 11.3% and transportation for 4.5%.

Table 44. SM millipoint scores for AIR-SHIELD LOW TEMP per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.56E-01	8.27E-03	2.09E-02	**1.85E-01**

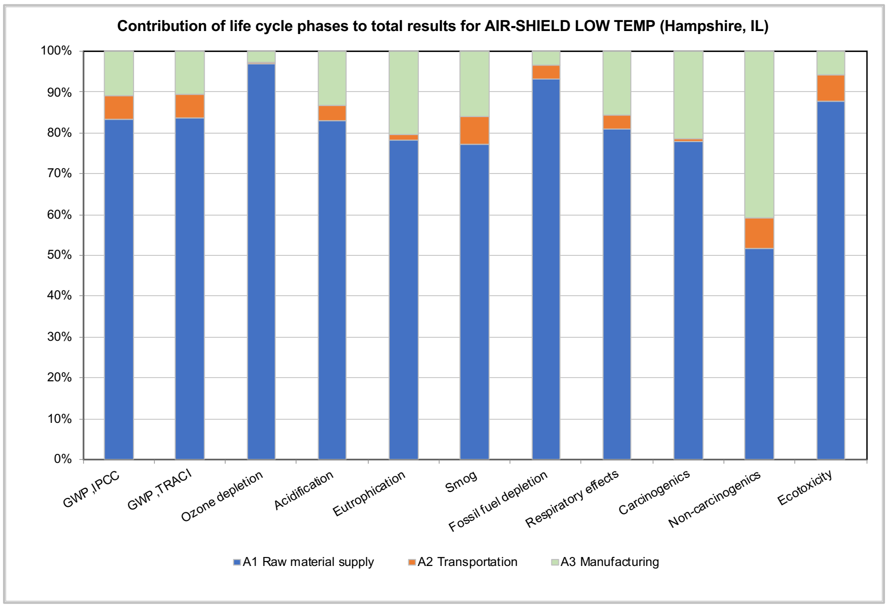

Figure 6. Contribution analysis of each impact category for AIR-SHIELD LOW TEMP

5.3.3. AIR-SHIELD XLT (Hampshire, IL)

Table 45 shows the LCIA results, and Table 46 and Figure 7 show the percent contribution of each stage of the production of the AIR-SHIELD XLT. The raw material acquisition stage dominates the results for all impact categories, followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD XLT production is 2.02 kg CO_2-eq. Raw material supply contributes 1.70 kg CO_2-eq, accounting for 84.3% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and ecotoxicity were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 10.2% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

Table 45. Life cycle impact assessment results for AIR-SHIELD XLT per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{TOTAL}$	kg CO_2 eq	1.73E+00	1.13E-01	2.14E-01	**2.05E+00**
GWP, IPCC$_{BIOGENIC}$	kg CO_2 eq	-1.52E-02	0	1.52E-02	**0**
GWP, IPCC$_{FOSSIL}$	kg CO_2 eq	1.74E+00	1.13E-01	1.99E-01	**2.05E+00**
GWP, TRACI 2.1$_{TOTAL}$	kg CO_2 eq	1.69E+00	1.11E-01	2.21E-01	**2.02E+00**
GWP, TRACI 2.1$_{BIOGENIC}$	kg CO_2 eq	-1.52E-02	0	1.52E-02	**0**
GWP, TRACI$_{FOSSIL}$	kg CO_2 eq	1.70E+00	1.11E-01	2.06E-01	**2.02E+00**
Ozone depletion	kg CFC-11 eq	3.51E-07	1.60E-09	8.75E-09	**3.62E-07**
Acidification	kg SO_2 eq	6.56E-03	2.75E-04	1.02E-03	**7.85E-03**
Eutrophication	kg N eq	1.40E-03	1.87E-05	3.54E-04	**1.77E-03**
Smog	kg O_3 eq	8.63E-02	7.05E-03	1.73E-02	**1.11E-01**
Fossil fuel depletion	MJ surplus	6.54E+00	2.12E-01	2.44E-01	**6.99E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.00E-03	3.78E-05	1.93E-04	**1.23E-03**
Carcinogenics	CTUh	77.14%	0.79%	22.07%	**100%**
Non carcinogenics	CTUh	50.56%	6.99%	42.45%	**100%**
Ecotoxicity	CTUe	88.27%	5.94%	5.79%	**100%**

Table 46. Percent contributions of each stage to each impact category for AIR-SHIELD XLT

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{FOSSIL}$	84.09%	5.48%	10.43%	**100%**
GWP, TRACI$_{2.1}$	84.28%	5.51%	10.21%	**100%**
Ozone depletion	97.14%	0.44%	2.42%	**100%**
Acidification	83.49%	3.50%	13.01%	**100%**
Eutrophication	78.93%	1.06%	20.01%	**100%**
Smog	77.97%	6.37%	15.66%	**100%**
Fossil fuel depletion	93.48%	3.03%	3.49%	**100%**
Additional environmental information				
Respiratory effects	81.27%	3.07%	15.65%	**100%**
Carcinogenics	77.14%	0.79%	22.07%	**100%**
Non-carcinogenics	50.56%	6.99%	42.45%	**100%**
Ecotoxicity	88.27%	5.94%	5.79%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 47). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 84.4% of the total impacts, manufacturing for 11.4% and transportation for 4.2%.

Table 47. SM millipoint scores for or AIR-SHIELD XLT per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.36E-01	6.73E-03	1.83E-02	**1.61E-01**

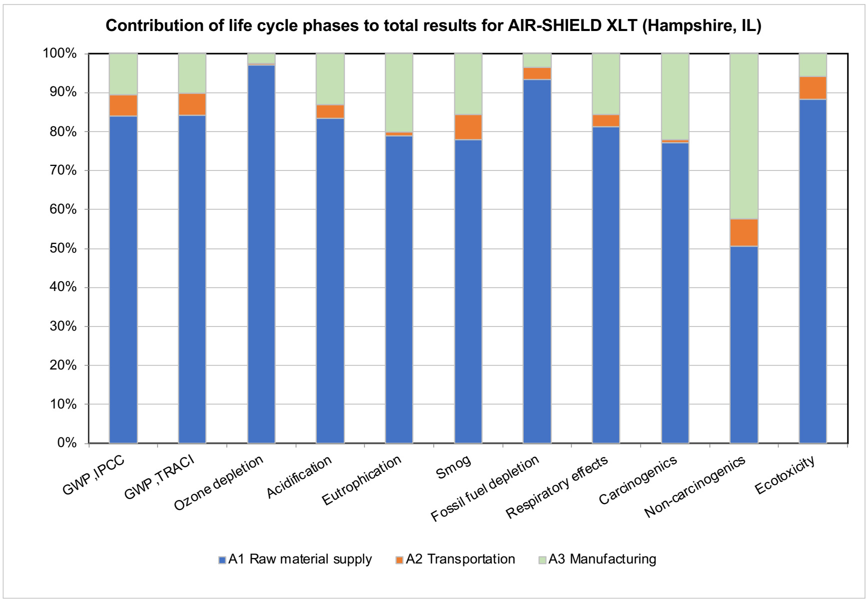

Figure 7. Contribution analysis of each impact category for AIR-SHIELD XLT

5.3.4. AIR-SHIELD LMP (Cartersville, GA; Fort Worth, TX; Hampshire IL)

This section discloses the TRACI impact categories for AIR-SHIELD LMP produced in three manufacturing locations: Cartersville, GA; Fort Worth, TX; and Hampshire, IL. Table 48, Table 51, and Table 54 show the LCIA results, and Table 49,
Table 52, Table 55 along with Figure 8, Figure 9, and Figure 10 show the percent contribution of each stage of the production of AIR-SHIELD LMP. The raw material acquisition stage dominates the results for all impact categories across all plant locations, followed by the manufacturing stage.

Across all locations, the total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD LMP production is 3.79-3.95 kg CO_2-eq. Raw material supply contributes 3.01-3.03 kg CO_2-eq, accounting for 77.5-86.4% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and eutrophication were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 16-17% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 50,Table 53, and Table 56). Across all locations, the SM single-figure score indicates that raw materials acquisition accounts for around 78.0-80.3% of the total impacts across all ten impact categories, manufacturing for 15.7-16.2% and transportation for 3.0-6.3%.

5.3.4.1. Cartersville, GA

Table 48. Life cycle impact assessment results for AIR-SHIELD LMP in Cartersville, GA per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	3.09E+00	1.10E-01	6.19E-01	**3.82E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	3.09E+00	1.10E-01	6.19E-01	**3.82E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	3.01E+00	1.09E-01	6.68E-01	**3.79E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	3.01E+00	1.09E-01	6.68E-01	**3.79E+00**
Ozone depletion	kg CFC-11 eq	1.05E-07	1.68E-09	1.01E-08	**1.17E-07**
Acidification	kg SO_2 eq	9.82E-03	1.29E-04	2.31E-03	**1.23E-02**
Eutrophication	kg N eq	2.21E-03	9.43E-06	3.31E-04	**2.55E-03**
Smog	kg O_3 eq	1.32E-01	1.98E-03	3.85E-02	**1.73E-01**
Fossil fuel depletion	MJ surplus	1.04E+01	2.07E-01	9.95E-01	**1.16E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.62E-03	3.38E-05	4.94E-04	**2.15E-03**
Carcinogenics	CTUh	55.88%	0.73%	43.39%	**9.45E-09**
Non carcinogenics	CTUh	62.85%	7.01%	30.14%	**1.95E-07**
Ecotoxicity	CTUe	66.85%	8.12%	25.03%	**3.45E+00**

Table 49. Percent contributions of each stage to each impact category for AIR-SHIELD LMP in Cartersville, GA

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	80.92%	2.88%	16.20%	**100%**
GWP, $TRACI_{2.1}$	79.50%	2.87%	17.63%	**100%**
Ozone depletion	89.94%	1.44%	8.62%	**100%**
Acidification	80.07%	1.05%	18.88%	**100%**
Eutrophication	86.64%	0.37%	12.99%	**100%**
Smog	76.55%	1.15%	22.30%	**100%**
Fossil fuel depletion	89.65%	1.78%	8.57%	**100%**
Additional environmental information				
Respiratory effects	75.44%	1.57%	22.99%	**100%**
Carcinogenics	55.88%	0.73%	43.39%	**100%**
Non-carcinogenics	62.85%	7.01%	30.14%	**100%**
Ecotoxicity	66.85%	8.12%	25.03%	**100%**

Table 50. SM millipoint scores for AIR-SHIELD LMP in Cartersville, GA per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.74E-01	6.37E-03	3.99E-02	**2.20E-01**

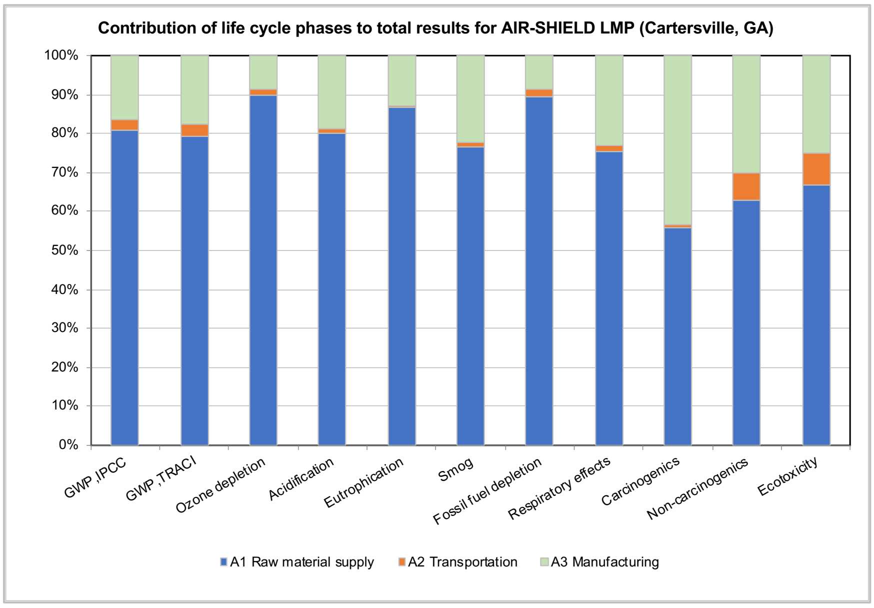

Figure 8. Contribution analysis of each impact category for AIR-SHIELD LMP in Cartersville, GA

5.3.4.2. Fort Worth, TX

Table 51. Life cycle impact assessment results for AIR-SHIELD LMP in Fort Worth, TX per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	3.09E+00	1.92E-01	6.06E-01	**3.89E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	3.09E+00	1.92E-01	6.06E-01	**3.89E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	3.01E+00	1.90E-01	6.56E-01	**3.86E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	3.01E+00	1.90E-01	6.56E-01	**3.86E+00**
Ozone depletion	kg CFC-11 eq	1.05E-07	2.94E-09	9.26E-09	**1.17E-07**
Acidification	kg SO_2 eq	9.82E-03	2.25E-04	2.28E-03	**1.23E-02**
Eutrophication	kg N eq	2.21E-03	1.65E-05	3.27E-04	**2.55E-03**
Smog	kg O_3 eq	1.32E-01	3.47E-03	3.81E-02	**1.74E-01**
Fossil fuel depletion	MJ surplus	1.04E+01	3.62E-01	9.78E-01	**1.18E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.62E-03	5.91E-05	4.91E-04	**2.17E-03**
Carcinogenics	CTUh	55.70%	1.27%	43.02%	**100%**
Non carcinogenics	CTUh	59.97%	11.70%	28.33%	**100%**
Ecotoxicity	CTUe	63.05%	13.38%	23.57%	**100%**

Table 52. Percent contributions of each stage to each impact category for AIR-SHIELD LMP in Fort Worth, TX

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	79.48%	4.94%	15.59%	**100%**
GWP, $TRACI_{2.1}$	78.09%	4.92%	16.99%	**100%**
Ozone depletion	89.59%	2.51%	7.90%	**100%**
Acidification	79.64%	1.83%	18.53%	**100%**
Eutrophication	86.54%	0.65%	12.82%	**100%**
Smog	76.08%	2.00%	21.92%	**100%**
Fossil fuel depletion	88.60%	3.08%	8.32%	**100%**
Additional environmental information				
Respiratory effects	74.67%	2.72%	22.61%	**100%**
Carcinogenics	55.70%	1.27%	43.02%	**100%**
Non-carcinogenics	59.97%	11.70%	28.33%	**100%**
Ecotoxicity	63.05%	13.38%	23.57%	**100%**

Table 53. SM millipoint scores for AIR-SHIELD LMP in Fort Worth, TX per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.74E-01	1.11E-02	3.94E-02	**2.24E-01**

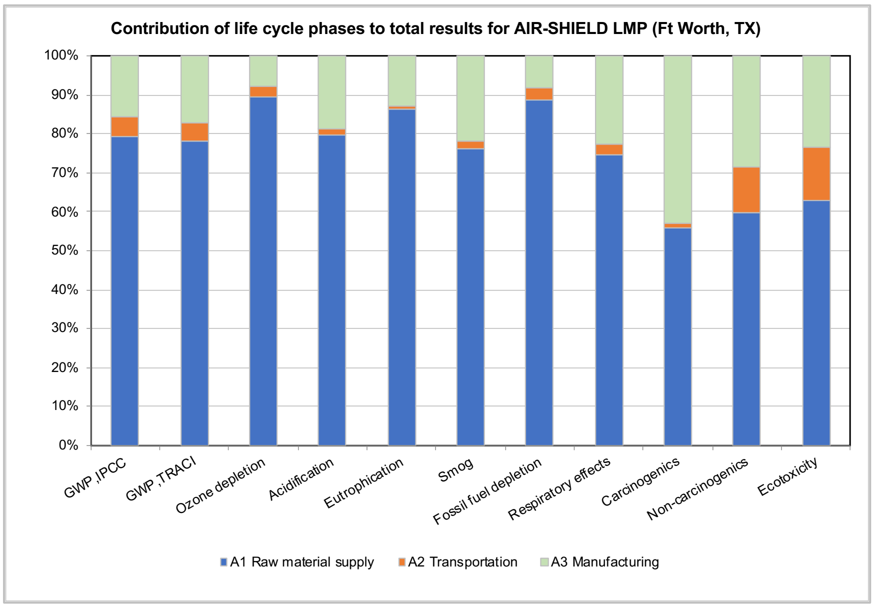

Figure 9. Contribution analysis of each impact category for AIR-SHIELD LMP in Fort Worth, TX

5.3.4.3. Hampshire, IL

Table 54. Life cycle impact assessment results for AIR-SHIELD LMP in Hampshire, IL per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	3.09E+00	2.41E-01	6.47E-01	**3.98E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	3.09E+00	2.41E-01	6.46E-01	**3.98E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	3.01E+00	2.38E-01	6.96E-01	**3.95E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	3.01E+00	2.38E-01	6.95E-01	**3.95E+00**
Ozone depletion	kg CFC-11 eq	1.05E-07	3.70E-09	1.27E-08	**1.21E-07**
Acidification	kg SO_2 eq	9.82E-03	2.83E-04	2.55E-03	**1.27E-02**
Eutrophication	kg N eq	2.21E-03	2.07E-05	3.48E-04	**2.58E-03**
Smog	kg O_3 eq	1.32E-01	4.35E-03	4.02E-02	**1.77E-01**
Fossil fuel depletion	MJ surplus	1.04E+01	4.55E-01	9.88E-01	**1.19E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.62E-03	7.42E-05	5.07E-04	**2.20E-03**
Carcinogenics	CTUh	54.68%	1.57%	43.75%	**100%**
Non carcinogenics	CTUh	57.65%	14.13%	28.22%	**100%**
Ecotoxicity	CTUe	60.88%	16.23%	22.89%	**100%**

Table 55. Percent contributions of each stage to each impact category for AIR-SHIELD LMP in Hampshire, IL

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	77.69%	6.06%	16.25%	**100%**
GWP, $TRACI_{2.1}$	76.33%	6.04%	17.62%	**100%**
Ozone depletion	86.47%	3.05%	10.48%	**100%**
Acidification	77.58%	2.24%	20.18%	**100%**
Eutrophication	85.70%	0.80%	13.50%	**100%**
Smog	74.80%	2.47%	22.73%	**100%**
Fossil fuel depletion	87.83%	3.84%	8.33%	**100%**
Additional environmental information				
Respiratory effects	73.64%	3.37%	22.99%	**100%**
Carcinogenics	54.68%	1.57%	43.75%	**100%**
Non-carcinogenics	57.65%	14.13%	28.22%	**100%**
Ecotoxicity	60.88%	16.23%	22.89%	**100%**

Table 56. SM millipoint scores for AIR-SHIELD LMP in Hampshire, IL per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.74E-01	1.40E-02	4.08E-02	**2.29E-01**

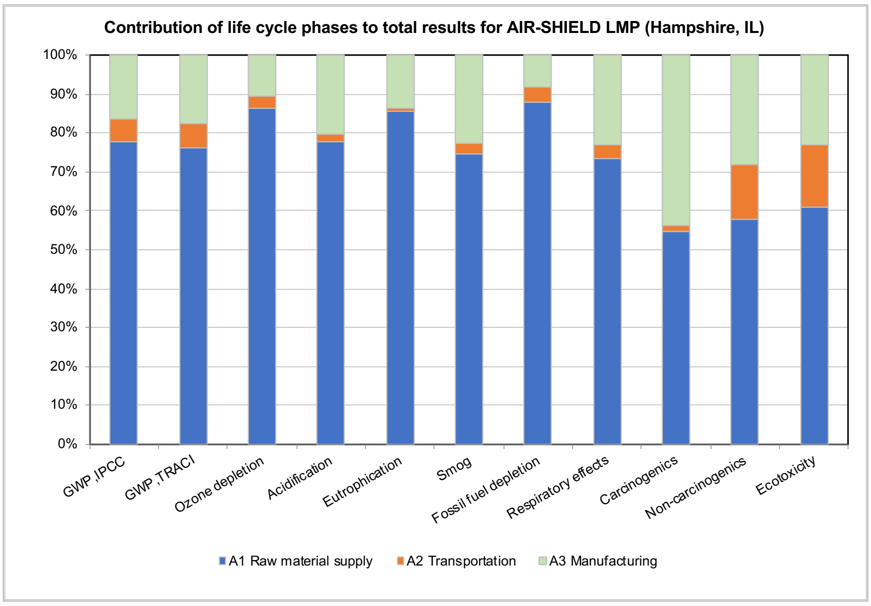

Figure 10. Contribution analysis of each impact category for AIR-SHIELD LMP in Hampshire, IL

5.3.5. AIR-SHIELD LSR (Cartersville, GA; Fort Worth, TX; Hampshire IL)

This section discloses the TRACI impact categories for AIR-SHIELD LSR produced in three manufacturing locations: Cartersville, GA; Fort Worth, TX; and Hampshire, IL. Table 57, Table 60, and Table 63 show the LCIA results, and Table 58, Table 61, and Table 64 along with Figure 11, Figure 12, and Figure 13 show the percent contribution of each stage of the production of AIR-SHIELD LSR. The raw material acquisition stage dominates the results for all impact categories across all plant locations, followed by the manufacturing stage.

Across all locations, the total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD LSR production is 5.98-6.43 kg CO_2-eq. Raw material supply contributes 5.11 kg CO_2-eq, accounting for 79.4-85.4% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and respiratory effects were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 11.5-12.5% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 59, Table 62, and Table 65). Across all locations, the SM single-figure score indicates that raw materials acquisition accounts for around 80.8-87.1% of the total impacts across all ten impact categories, manufacturing for 9.8-10.7% and transportation for 2.2-9.4%.

5.3.5.1. Cartersville, GA

Table 57. Life cycle impact assessment results for AIR-SHIELD LSR in Cartersville, GA per declared unit ($1 m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	5.26E+00	1.29E-01	6.29E-01	**6.02E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-5.72E-04	0	5.72E-04	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	5.26E+00	1.29E-01	6.28E-01	**6.02E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	5.11E+00	1.27E-01	7.48E-01	**5.99E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	5.11E+00	1.27E-01	7.48E-01	**5.99E+00**
Ozone depletion	kg CFC-11 eq	1.90E-07	1.98E-09	3.62E-09	**1.95E-07**
Acidification	kg SO_2 eq	1.49E-02	1.51E-04	1.48E-03	**1.66E-02**
Eutrophication	kg N eq	2.49E-03	1.11E-05	2.74E-04	**2.78E-03**
Smog	kg O_3 eq	1.99E-01	2.33E-03	2.24E-02	**2.24E-01**
Fossil fuel depletion	MJ surplus	1.97E+01	2.43E-01	4.57E-01	**2.04E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	2.32E-03	3.97E-05	1.77E-04	**2.54E-03**
Carcinogenics	CTUh	51.30%	0.61%	48.10%	**100%**
Non carcinogenics	CTUh	73.30%	6.29%	20.42%	**100%**
Ecotoxicity	CTUe	82.99%	6.60%	10.41%	**100%**

Table 58. Percent contributions of each stage to each impact category for AIR-SHIELD LSR in Cartersville, GA

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	85.38%	2.13%	12.49%	**100%**
GWP, $TRACI_{2.1}$	97.13%	1.01%	1.86%	**100%**
Ozone depletion	90.14%	0.91%	8.95%	**100%**
Acidification	89.74%	0.40%	9.86%	**100%**
Eutrophication	88.92%	1.04%	10.04%	**100%**
Smog	96.57%	1.19%	2.24%	**100%**
Fossil fuel depletion	85.38%	2.13%	12.49%	**100%**
Additional environmental information				
Respiratory effects	91.49%	1.56%	6.95%	**100%**
Carcinogenics	51.30%	0.61%	48.10%	**100%**
Non-carcinogenics	73.30%	6.29%	20.42%	**100%**
Ecotoxicity	82.99%	6.60%	10.41%	**100%**

Table 59. SM millipoint scores for AIR-SHIELD LSR in Cartersville, GA per declared unit ($1 m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	2.98E-01	7.48E-03	3.62E-02	**3.42E-01**

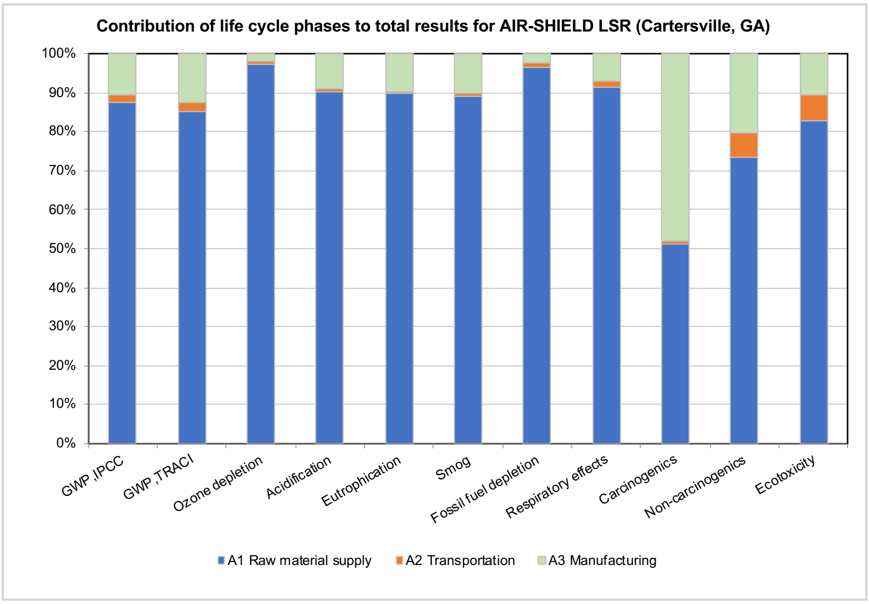

Figure 11. Contribution analysis of each impact category for AIR-SHIELD LSR in Cartersville, GA

5.3.5.2. Fort Worth, TX

Table 60. Life cycle impact assessment results for AIR-SHIELD LSR in Fort Worth, TX per declared unit (1m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{TOTAL}$	kg CO_2 eq	5.26E+00	5.91E-01	6.22E-01	**6.48E+00**
GWP, IPCC$_{BIOGENIC}$	kg CO_2 eq	-5.72E-04	0	5.72E-04	**0**
GWP, IPCC$_{FOSSIL}$	kg CO_2 eq	5.26E+00	5.91E-01	6.21E-01	**6.48E+00**
GWP, TRACI 2.1$_{TOTAL}$	kg CO_2 eq	5.11E+00	5.84E-01	7.42E-01	**6.44E+00**
GWP, TRACI 2.1$_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, TRACI$_{FOSSIL}$	kg CO_2 eq	5.11E+00	5.84E-01	7.41E-01	**6.44E+00**
Ozone depletion	kg CFC-11 eq	1.90E-07	9.06E-09	2.81E-09	**2.01E-07**
Acidification	kg SO_2 eq	1.49E-02	6.94E-04	1.48E-03	**1.71E-02**
Eutrophication	kg N eq	2.49E-03	5.07E-05	2.71E-04	**2.81E-03**
Smog	kg O_3 eq	1.99E-01	1.07E-02	2.22E-02	**2.32E-01**
Fossil fuel depletion	MJ surplus	1.97E+01	1.12E+00	4.48E-01	**2.13E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	2.32E-03	1.82E-04	1.74E-04	**2.68E-03**
Carcinogenics	CTUh	50.25%	2.72%	47.02%	**100%**
Non carcinogenics	CTUh	60%	23.59%	16.41%	**100%**
Ecotoxicity	CTUe	67.13%	24.47%	8.40%	**100%**

Table 61. Percent contributions of each stage to each impact category for AIR-SHIELD LSR in Fort Worth, TX

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{FOSSIL}$	81.27%	9.13%	9.60%	**100%**
GWP, TRACI$_{2.1}$	79.41%	9.07%	11.51%	**100%**
Ozone depletion	94.11%	4.50%	1.39%	**100%**
Acidification	87.31%	4.06%	8.63%	**100%**
Eutrophication	88.58%	1.80%	9.62%	**100%**
Smog	85.82%	4.61%	9.57%	**100%**
Fossil fuel depletion	92.65%	5.24%	2.11%	**100%**
Additional environmental information				
Respiratory effects	86.72%	6.78%	6.50%	**100%**
Carcinogenics	50.25%	2.72%	47.02%	**100%**
Non-carcinogenics	60%	23.59%	16.41%	**100%**
Ecotoxicity	67.13%	24.47%	8.40%	**100%**

Table 62. SM millipoint scores for AIR-SHIELD LSR in Fort Worth, TX per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	2.98E-01	3.43E-02	3.59E-02	**3.69E-01**

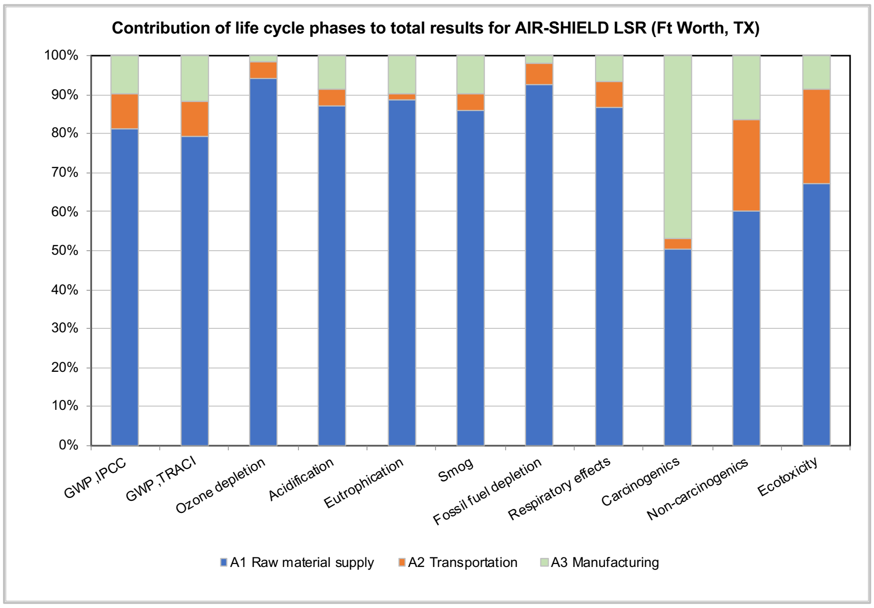

Figure 12. Contribution analysis of each impact category for AIR-SHIELD LSR in Fort Worth, TX

5.3.5.3. Hampshire, IL

Table 63. Life cycle impact assessment results for AIR-SHIELD LSR in Hampshire, IL per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{TOTAL}$	kg CO_2 eq	5.26E+00	3.61E-01	6.22E-01	**6.25E+00**
GWP, IPCC$_{BIOGENIC}$	kg CO_2 eq	-5.72E-04	0	5.72E-04	**0**
GWP, IPCC$_{FOSSIL}$	kg CO_2 eq	5.26E+00	3.61E-01	6.21E-01	**6.25E+00**
GWP, TRACI 2.1$_{TOTAL}$	kg CO_2 eq	5.11E+00	3.57E-01	7.42E-01	**6.21E+00**
GWP, TRACI 2.1$_{BIOGENIC}$	kg CO_2 eq	-1.20E-04	0	1.20E-04	**0**
GWP, TRACI$_{FOSSIL}$	kg CO_2 eq	5.11E+00	3.57E-01	7.41E-01	**6.21E+00**
Ozone depletion	kg CFC-11 eq	1.90E-07	5.53E-09	2.81E-09	**1.98E-07**
Acidification	kg SO_2 eq	1.49E-02	4.23E-04	1.48E-03	**1.68E-02**
Eutrophication	kg N eq	2.49E-03	3.10E-05	2.67E-04	**2.79E-03**
Smog	kg O_3 eq	1.99E-01	6.51E-03	2.22E-02	**2.28E-01**
Fossil fuel depletion	MJ surplus	1.97E+01	6.81E-01	4.48E-01	**2.09E+01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	2.32E-03	1.11E-04	1.74E-04	**2.61E-03**
Carcinogenics	CTUh	50.80%	1.68%	47.52%	**100%**
Non carcinogenics	CTUh	66.11%	15.86%	18.03%	**100%**
Ecotoxicity	CTUe	74.21%	16.51%	9.28%	**100%**

Table 64. Percent contributions of each stage to each impact category for AIR-SHIELD LSR in Hampshire, IL

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	84.27%	5.78%	9.95%	**100%**
GWP, $TRACI_{2.1}$	82.32%	5.74%	11.94%	**100%**
Ozone depletion	95.79%	2.79%	1.42%	**100%**
Acidification	88.72%	2.52%	8.77%	**100%**
Eutrophication	89.34%	1.11%	9.55%	**100%**
Smog	87.39%	2.86%	9.74%	**100%**
Fossil fuel depletion	94.59%	3.26%	2.15%	**100%**
Additional environmental information				
Respiratory effects	89.07%	4.25%	6.68%	**100%**
Carcinogenics	50.80%	1.68%	47.52%	**100%**
Non-carcinogenics	66.11%	15.86%	18.03%	**100%**
Ecotoxicity	74.21%	16.51%	9.28%	**100%**

Table 65. SM millipoint scores for AIR-SHIELD LSR in Hampshire, IL per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	2.98E-01	2.09E-02	3.59E-02	**3.55E-01**

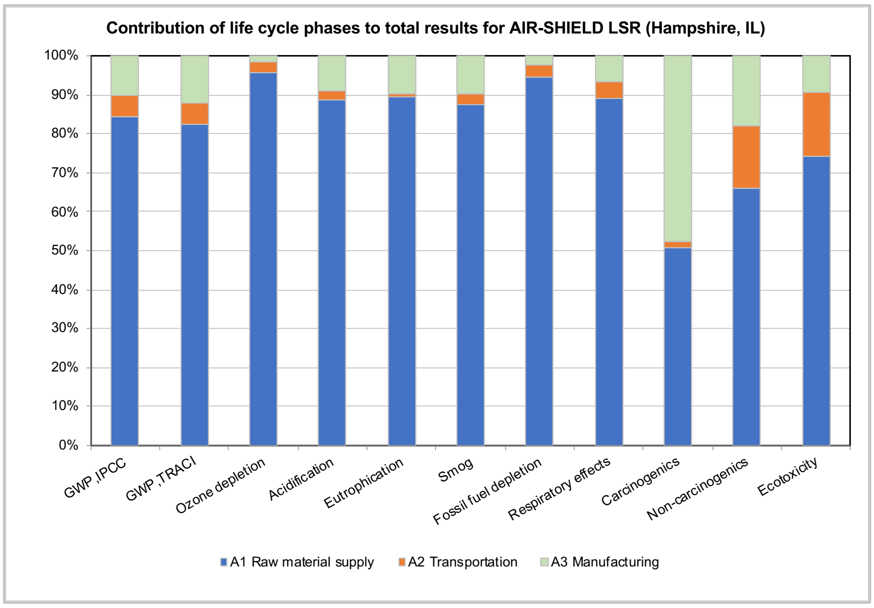

Figure 13. Contribution analysis of each impact category for AIR-SHIELD LSR in Hampshire, IL

5.3.6. AIR-SHIELD TMP (Cartersville, GA; Fort Worth, TX; Hampshire IL)

This section discloses the TRACI impact categories for AIR-SHIELD TMP produced in three manufacturing locations: Cartersville, GA; Fort Worth, TX; and Hampshire, IL. Table 66, Table 69, and Table 72 show the LCIA results, and Table 67, Table 70, and Table **73** along with

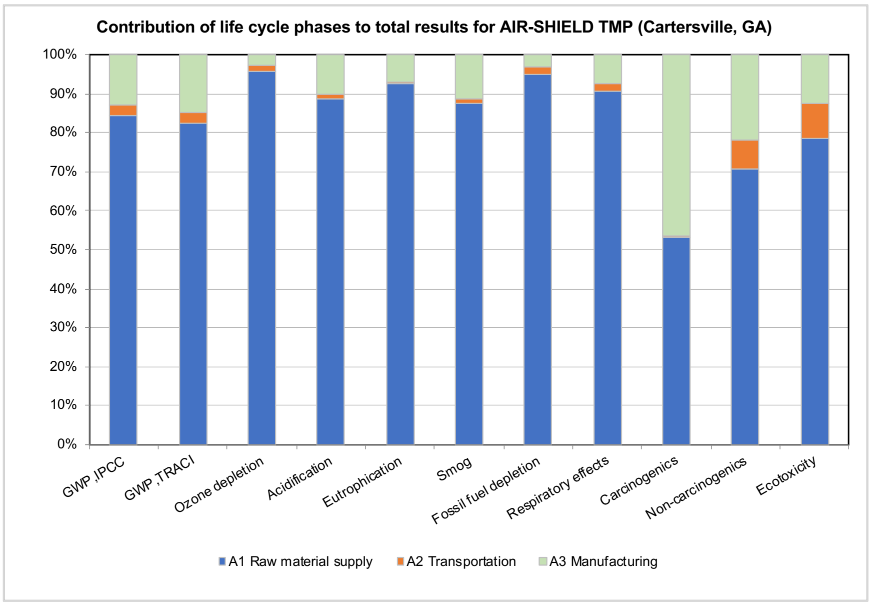

Figure 14, Figure 15, and Figure 16 show the percent contribution of each stage of the production of AIR-SHIELD TMP. The raw material acquisition stage dominates the results for all impact categories across all plant locations, followed by the manufacturing stage.

Across all locations, the total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of AIR-SHIELD TMP production is 1.04-1.09 kg CO_2-eq. Raw material supply contributes 0.824 kg CO_2-eq, accounting for 78.1-82.0% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and eutrophication were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 14.5-15.1% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 59, Table 62, and Table 65). Across all locations, the SM single-figure score indicates that raw materials acquisition accounts for around 79.4-83.5% of the total impacts across all ten impact categories, manufacturing for 12.8-13.4% and transportation for 3.1-7.8%.

5.3.6.1. Cartersville, GA

Table 66. Life cycle impact assessment results for AIR-SHIELD TMP in Cartersville, GA per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	8.79E-01	2.98E-02	1.34E-01	**1.04E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	8.79E-01	2.98E-02	1.34E-01	**1.04E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	8.56E-01	2.94E-02	1.52E-01	**1.04E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	8.56E-01	2.94E-02	1.52E-01	**1.04E+00**
Ozone depletion	kg CFC-11 eq	2.99E-08	4.56E-10	8.22E-10	**3.11E-08**
Acidification	kg SO_2 eq	2.79E-03	3.49E-05	3.20E-04	**3.15E-03**
Eutrophication	kg N eq	6.28E-04	2.56E-06	4.75E-05	**6.78E-04**
Smog	kg O_3 eq	3.76E-02	5.38E-04	4.84E-03	**4.29E-02**
Fossil fuel depletion	MJ surplus	2.97E+00	5.62E-02	1.01E-01	**3.12E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	4.62E-04	9.16E-06	3.83E-05	**5.09E-04**
Carcinogenics	CTUh	52.98%	0.66%	46.36%	**100%**
Non carcinogenics	CTUh	70.71%	7.53%	21.76%	**100%**
Ecotoxicity	CTUe	78.36%	9.06%	12.59%	**100%**

Table 67. Percent contributions of each stage to each impact category for AIR-SHIELD TMP in Cartersville, GA

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	84.25%	2.86%	12.89%	**100%**
GWP, $TRACI_{2.1}$	82.54%	2.84%	14.62%	**100%**
Ozone depletion	95.90%	1.47%	2.64%	**100%**
Acidification	88.73%	1.11%	10.16%	**100%**
Eutrophication	92.62%	0.38%	7.00%	**100%**
Smog	87.49%	1.25%	11.26%	**100%**
Fossil fuel depletion	94.97%	1.80%	3.23%	**100%**
Additional environmental information				
Respiratory effects	90.68%	1.80%	7.53%	**100%**
Carcinogenics	52.98%	0.66%	46.36%	**100%**
Non-carcinogenics	70.71%	7.53%	21.76%	**100%**
Ecotoxicity	78.36%	9.06%	12.59%	**100%**

Table 68. SM millipoint scores for AIR-SHIELD TMP in Cartersville, GA per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.95E-02	1.73E-03	7.42E-03	**5.86E-02**

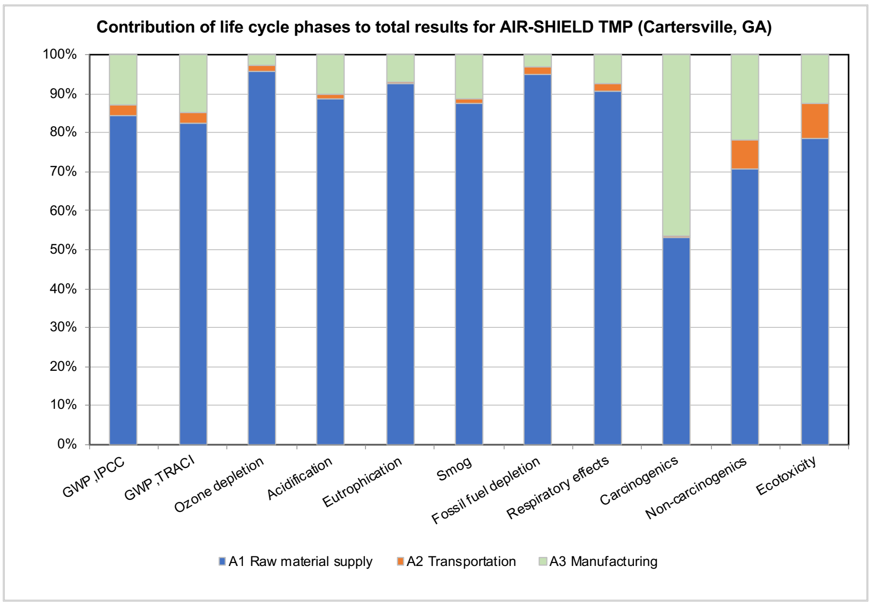

Figure 14. Contribution analysis of each impact category for AIR-SHIELD TMP in Cartersville, GA

5.3.6.2. Fort Worth, TX

Table 69. Life cycle impact assessment results for AIR-SHIELD TMP in Fort Worth, TX per declared unit ($1m^2$)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	8.79E-01	5.41E-02	1.33E-01	**1.07E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	8.79E-01	5.41E-02	1.33E-01	**1.07E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	8.56E-01	5.35E-02	1.50E-01	**1.06E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	8.56E-01	5.35E-02	1.50E-01	**1.06E+00**
Ozone depletion	kg CFC-11 eq	2.99E-08	8.29E-10	6.44E-10	**3.13E-08**
Acidification	kg SO_2 eq	2.79E-03	6.35E-05	3.18E-04	**3.17E-03**
Eutrophication	kg N eq	6.28E-04	4.64E-06	4.69E-05	**6.80E-04**
Smog	kg O_3 eq	3.76E-02	9.76E-04	4.78E-03	**4.33E-02**
Fossil fuel depletion	MJ surplus	2.97E+00	1.02E-01	9.90E-02	**3.17E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	4.62E-04	1.66E-05	3.78E-05	**5.16E-04**
Carcinogenics	CTUh	52.74%	1.20%	46.06%	**100%**
Non carcinogenics	CTUh	66.88%	12.94%	20.19%	**100%**
Ecotoxicity	CTUe	72.99%	15.32%	11.69%	**100%**

Table 70. Percent contributions of each stage to each impact category for AIR-SHIELD LSR in Fort Worth, TX

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	82.44%	5.07%	12.48%	**100%**
GWP, $TRACI_{2.1}$	80.78%	5.04%	14.18%	**100%**
Ozone depletion	95.30%	2.64%	2.05%	**100%**
Acidification	87.97%	2.00%	10.03%	**100%**
Eutrophication	92.42%	0.68%	6.90%	**100%**
Smog	86.72%	2.25%	11.03%	**100%**
Fossil fuel depletion	93.65%	3.22%	3.13%	**100%**
Additional environmental information				
Respiratory effects	89.45%	3.22%	7.33%	**100%**
Carcinogenics	52.74%	1.20%	46.06%	**100%**
Non-carcinogenics	66.88%	12.94%	20.19%	**100%**
Ecotoxicity	72.99%	15.32%	11.69%	**100%**

Table 71. SM millipoint scores for AIR-SHIELD TMP in Fort Worth, TX per declared unit (1m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.95E-02	3.14E-03	7.36E-03	**6.00E-02**

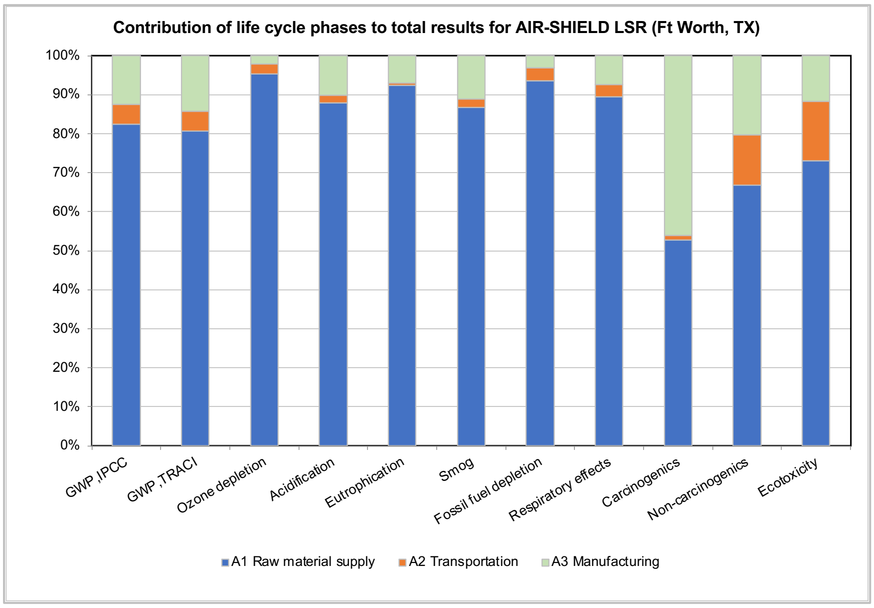

Figure 15. Contribution analysis of each impact category for AIR-SHIELD TMP in Fort Worth, TX

5.3.6.3. Hampshire, IL

Table 72. Life cycle impact assessment results for AIR-SHIELD TMP in Hampshire, IL per declared unit (1m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, IPCC$_{TOTAL}$	kg CO_2 eq	8.79E-01	7.83E-02	1.36E-01	**1.09E+00**
GWP, IPCC$_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, IPCC$_{FOSSIL}$	kg CO_2 eq	8.79E-01	7.83E-02	1.36E-01	**1.09E+00**
GWP, TRACI 2.1$_{TOTAL}$	kg CO_2 eq	8.56E-01	7.74E-02	1.53E-01	**1.09E+00**
GWP, TRACI 2.1$_{BIOGENIC}$	kg CO_2 eq	0	0	0	**0**
GWP, TRACI$_{FOSSIL}$	kg CO_2 eq	8.56E-01	7.74E-02	1.53E-01	**1.09E+00**
Ozone depletion	kg CFC-11 eq	2.99E-08	1.20E-09	1.24E-09	**3.23E-08**
Acidification	kg SO_2 eq	2.79E-03	9.19E-05	3.57E-04	**3.24E-03**
Eutrophication	kg N eq	6.28E-04	6.72E-06	5.04E-05	**6.86E-04**
Smog	kg O_3 eq	3.76E-02	1.41E-03	5.06E-03	**4.40E-02**
Fossil fuel depletion	MJ surplus	2.97E+00	1.48E-01	9.31E-02	**3.21E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	4.62E-04	2.41E-05	4.00E-05	**5.26E-04**
Carcinogenics	CTUh	52.07%	1.71%	46.21%	**100%**
Non carcinogenics	CTUh	62.84%	17.60%	19.56%	**100%**
Ecotoxicity	CTUe	68.23%	20.74%	11.03%	**100%**

Table 73. Percent contributions of each stage to each impact category for AIR-SHIELD TMP in Hampshire, IL

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	80.40%	7.17%	12.43%	**100%**
GWP, $TRACI_{2.1}$	78.78%	7.12%	14.09%	**100%**
Ozone depletion	92.44%	3.72%	3.84%	**100%**
Acidification	86.15%	2.84%	11.01%	**100%**
Eutrophication	91.67%	0.98%	7.35%	**100%**
Smog	85.30%	3.21%	11.49%	**100%**
Fossil fuel depletion	92.49%	4.61%	2.90%	**100%**
Additional environmental information				
Respiratory effects	87.81%	4.58%	7.61%	**100%**
Carcinogenics	52.07%	1.71%	46.21%	**100%**
Non-carcinogenics	62.84%	17.60%	19.56%	**100%**
Ecotoxicity	68.23%	20.74%	11.03%	**100%**

Table 74. SM millipoint scores for AIR-SHIELD TMP in Hampshire, IL per declared unit ($1m^2$)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.64E-02	4.54E-03	7.47E-03	**5.84E-02**

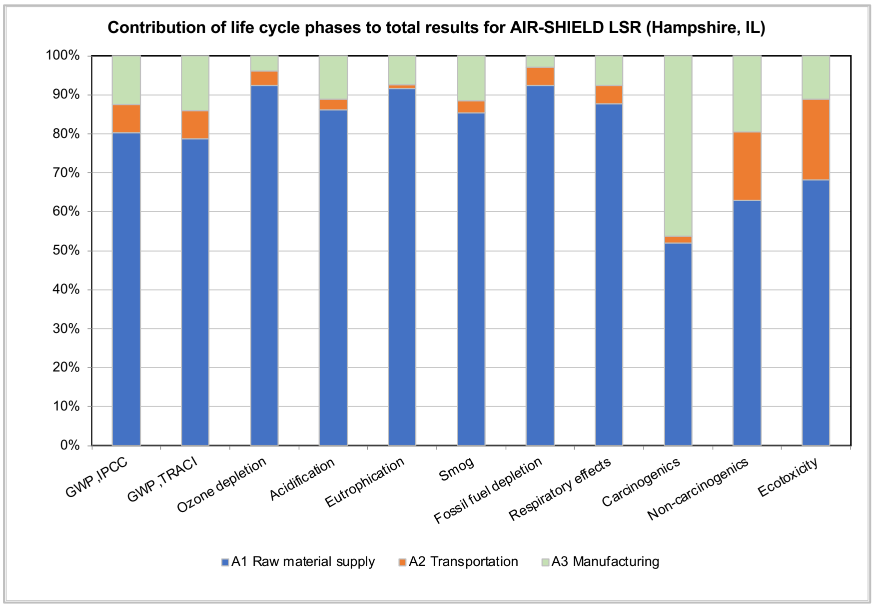

Figure 16. Contribution analysis of each impact category for AIR-SHIELD TMP in Hampshire, IL

5.3.7. MEL-ROL 60 Mil (Hampshire, IL)

Table 75 shows the LCIA results, and Table 76 and Figure 17 show the percent contribution of each stage of the production of MEL-ROL 60 mil. The raw material acquisition stage dominates the results for most impact categories (9 out of 10), followed by the manufacturing stage.

The total potential CO2-equivalent emissions generated during the cradle-to-gate stage of 1 m2 of MEL-ROL 60 Mil production is 1.85 kg CO2-eq. Raw material supply contributes 1.48 kg CO2-eq, accounting for 80.2% of the total results. The manufacturing stage was dominant for the non-carcinogenics impact category, contributing 54.8% of those results. However, the raw material acquisition stage has a larger contribution than the manufacturing stage for most impact categories including most notably ozone depletion (91.60%), fossil fuel depletion (91.70%), and ecotoxicity (89.66%). Transportation accounts for the least of the impacts among all impact categories.

Table 75. Life cycle impact assessment results for MEL-ROL 60 Mil per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	1.50E+00	1.04E-01	2.72E-01	**1.87E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.97E-02	0	1.97E-02	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	1.52E+00	1.04E-01	2.52E-01	**1.87E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	1.46E+00	1.03E-01	2.81E-01	**1.85E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.97E-02	0	1.97E-02	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	1.48E+00	1.03E-01	2.62E-01	**1.85E+00**
Ozone depletion	kg CFC-11 eq	3.47E-07	2.06E-08	1.12E-08	**3.79E-07**
Acidification	kg SO_2 eq	5.68E-03	3.24E-04	1.31E-03	**7.32E-03**
Eutrophication	kg N eq	1.04E-03	4.36E-05	4.54E-04	**1.54E-03**
Smog	kg O_3 eq	7.63E-02	8.52E-03	2.22E-02	**1.07E-01**
Fossil fuel depletion	MJ surplus	5.63E+00	1.98E-01	3.11E-01	**6.14E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	8.93E-04	2.03E-05	2.47E-04	**1.16E-03**
Carcinogenics	CTUh	68.95%	0.51%	30.53%	**100%**
Non carcinogenics	CTUh	43.22%	1.99%	54.79%	**100%**
Ecotoxicity	CTUe	89.66%	1.60%	8.73%	**100%**

Table 76. Percent contributions of each stage to each impact category for MEL-ROL 60 Mil

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	79.94%	5.54%	14.52%	**100%**
GWP, $TRACI_{2.1}$	80.23%	5.60%	14.17%	**100%**
Ozone depletion	91.60%	5.44%	2.96%	**100%**
Acidification	77.70%	4.43%	17.87%	**100%**
Eutrophication	67.62%	2.83%	29.55%	**100%**
Smog	71.32%	7.96%	20.72%	**100%**
Fossil fuel depletion	91.70%	3.23%	5.07%	**100%**
Additional environmental information				
Respiratory effects	76.98%	1.75%	21.27%	**100%**
Carcinogenics	68.95%	0.51%	30.53%	**100%**
Non-carcinogenics	43.22%	1.99%	54.79%	**100%**
Ecotoxicity	89.66%	1.60%	8.73%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 77). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 80.5% of the total impacts, manufacturing for 16.5%, and transportation for 3.0%.

Table 77. SM millipoint scores for MEL-ROL 60 Mil per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	1.13E-01	4.27E-03	2.31E-02	**1.40E-01**	1.13E-01

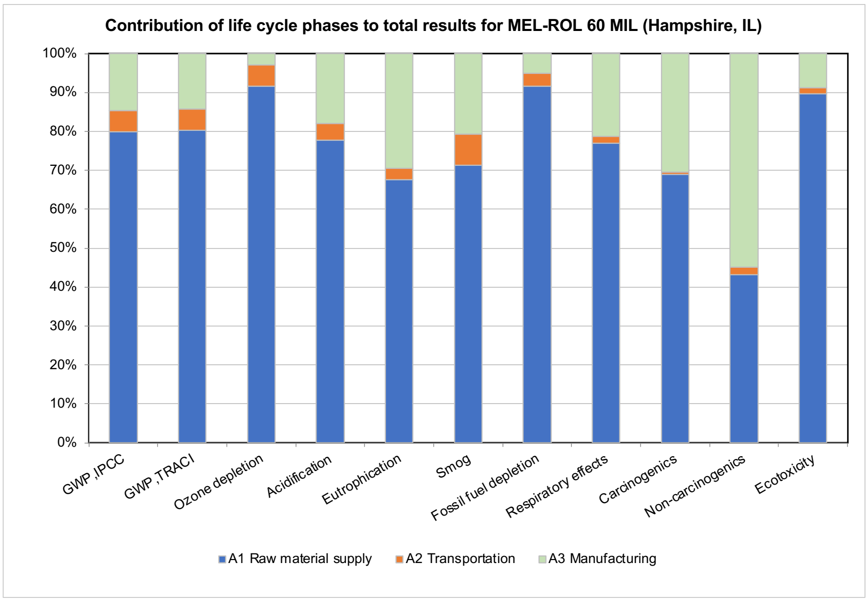

Figure 17. Contribution analysis of each impact category for MEL-ROL 60 mil

5.3.8. MEL-ROL LOW TEMP (Hampshire, IL)

Table 78 shows the LCIA results, and Table 79 and Figure 18 show the percent contribution of each stage of the production of MEL-ROL LOW TEMP. The raw material acquisition stage dominates the results for all impact categories, followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of MEL-ROL LOW-TEMP production is 2.36 kg CO_2-eq. Raw material supply contributes 1.94 kg CO_2-eq, accounting for 83.7% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and ecotoxicity were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 10.9% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

Table 78. Life cycle impact assessment for MEL-ROL LOW TEMP per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	1.97E+00	1.25E-01	2.64E-01	**2.36E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.89E-02	0	1.89E-02	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	1.99E+00	1.25E-01	2.45E-01	**2.36E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	1.92E+00	1.24E-01	2.72E-01	**2.32E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.89E-02	0	1.89E-02	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	1.94E+00	1.24E-01	2.53E-01	**2.32E+00**
Ozone depletion	kg CFC-11 eq	3.58E-07	2.48E-08	9.83E-09	**3.92E-07**
Acidification	kg SO_2 eq	7.59E-03	3.89E-04	1.23E-03	**9.21E-03**
Eutrophication	kg N eq	1.61E-03	5.24E-05	4.27E-04	**2.09E-03**
Smog	kg O_3 eq	1.00E-01	1.02E-02	2.09E-02	**1.32E-01**
Fossil fuel depletion	MJ surplus	7.46E+00	2.38E-01	3.04E-01	**8.00E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.17E-03	2.44E-05	2.28E-04	**1.42E-03**
Carcinogenics	CTUh	78.08%	0.48%	21.43%	**100%**
Non carcinogenics	CTUh	54.64%	2.19%	43.18%	**100%**
Ecotoxicity	CTUe	93.20%	1.34%	5.46%	**100%**

Table 79. Percent contributions of each stage to each impact category for MEL-ROL LOW TEMP

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	83.50%	5.30%	11.20%	**100%**
GWP, $TRACI_{2.1}$	83.71%	5.37%	10.92%	**100%**
Ozone depletion	91.18%	6.32%	2.50%	**100%**
Acidification	82.41%	4.23%	13.37%	**100%**
Eutrophication	77.12%	2.50%	20.38%	**100%**
Smog	76.37%	7.78%	15.86%	**100%**
Fossil fuel depletion	93.23%	2.98%	3.80%	**100%**
Additional environmental information				
Respiratory effects	82.19%	1.72%	16.09%	**100%**
Carcinogenics	78.08%	0.48%	21.43%	**100%**
Non-carcinogenics	54.64%	2.19%	43.18%	**100%**
Ecotoxicity	93.20%	1.34%	5.46%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 80). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 85.6% of the total impacts, manufacturing for 11.6%, and transportation for 2.8%.

Table 80. SM millipoint scores for MEL-ROL LOW TEMP per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.56E-01	5.13E-03	2.11E-02	**1.82E-01**

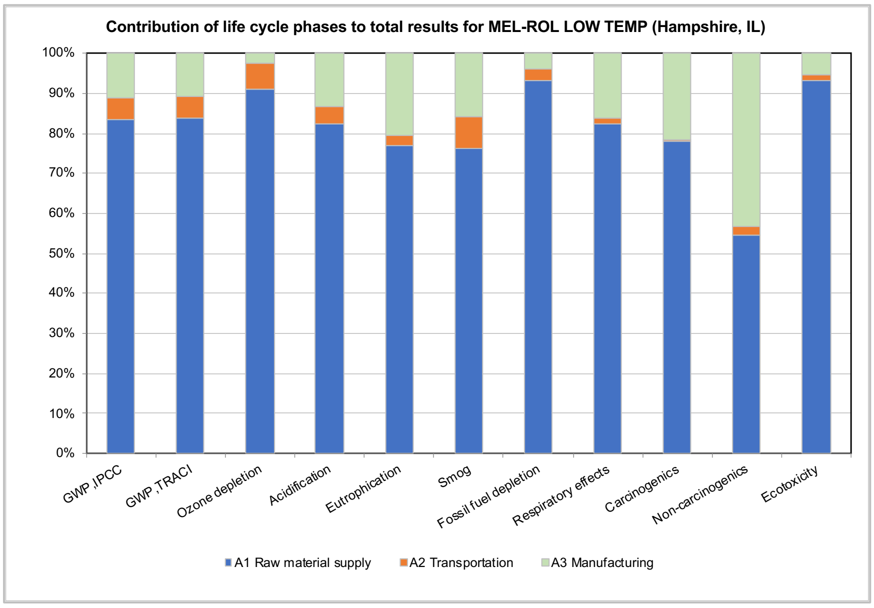

Figure 18. Contribution analysis of each impact category for MEL-ROL LOW TEMP

5.3.9. MEL-ROL XLT (Hampshire, IL)

Table 81 shows the LCIA results, and Table 82 and

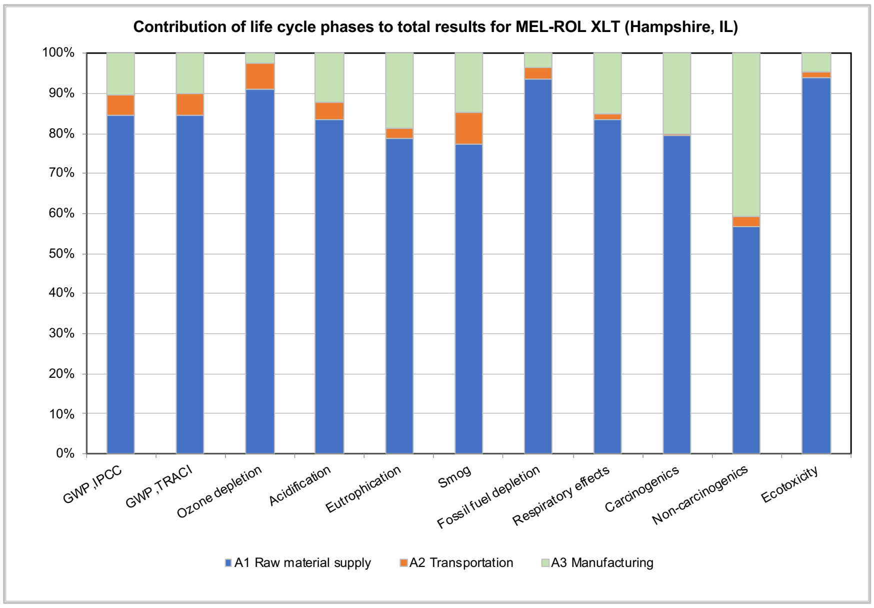

Figure 19 show the percent contribution of each stage of the production of MEL-ROL XLT. The raw material acquisition stage dominates the results for all impact categories, followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of 1 m^2 of MEL-ROL XLT production is 2.56 kg CO_2-eq. Raw material supply contributes 2.13 kg CO_2-eq, accounting for 84.6% of the total results. This is primarily due to the styrene butadiene copolymer used as a raw material input for this product. Ozone depletion, fossil fuel depletion, and ecotoxicity were the most impacted categories in this stage. The manufacturing stage was the second highest contributor (at 10.0% to GWP), mostly due to the energy required for production at the facility. Transportation accounts for the least of the impacts among all impact categories.

Table 81. Life cycle impact assessment for MEL-ROL XLT per declared unit (1 m^2)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	2.16E+00	1.35E-01	2.62E-01	**2.56E+00**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.86E-02	0	1.86E-02	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	2.18E+00	1.35E-01	2.44E-01	**2.56E+00**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	2.11E+00	1.34E-01	2.70E-01	**2.51E+00**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.86E-02	0	1.86E-02	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	2.13E+00	1.34E-01	2.52E-01	**2.51E+00**
Ozone depletion	kg CFC-11 eq	3.63E-07	2.68E-08	9.72E-09	**3.99E-07**
Acidification	kg SO_2 eq	8.26E-03	4.21E-04	1.22E-03	**9.91E-03**
Eutrophication	kg N eq	1.77E-03	5.66E-05	4.24E-04	**2.26E-03**
Smog	kg O_3 eq	1.09E-01	1.11E-02	2.08E-02	**1.41E-01**
Fossil fuel depletion	MJ surplus	8.17E+00	2.57E-01	3.02E-01	**8.73E+00**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.27E-03	2.64E-05	2.27E-04	**1.52E-03**
Carcinogenics	CTUh	79.45%	0.49%	20.06%	**100%**
Non carcinogenics	CTUh	56.90%	2.27%	40.84%	**100%**
Ecotoxicity	CTUe	93.88%	1.29%	4.83%	**100%**

Table 82. Percent contributions of each stage to each impact category for MEL-ROL XLT

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	84.47%	5.28%	10.25%	**100%**
GWP, $TRACI_{2.1}$	84.64%	5.35%	10.01%	**100%**
Ozone depletion	90.85%	6.72%	2.43%	**100%**
Acidification	83.39%	4.25%	12.36%	**100%**
Eutrophication	78.68%	2.51%	18.81%	**100%**
Smog	77.40%	7.86%	14.74%	**100%**
Fossil fuel depletion	93.60%	2.95%	3.46%	**100%**
Additional environmental information				
Respiratory effects	83.31%	1.74%	14.95%	**100%**
Carcinogenics	79.45%	0.49%	20.06%	**100%**
Non-carcinogenics	56.90%	2.27%	40.84%	**100%**
Ecotoxicity	93.88%	1.29%	4.83%	**100%**

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 83). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 86.6% of the total impacts, manufacturing for 10.6%, and transportation for 2.8%.

Table 83. SM millipoint scores for MEL-ROL XLT per declared unit (1 m^2)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.71E-01	5.55E-03	2.09E-02	**1.98E-01**

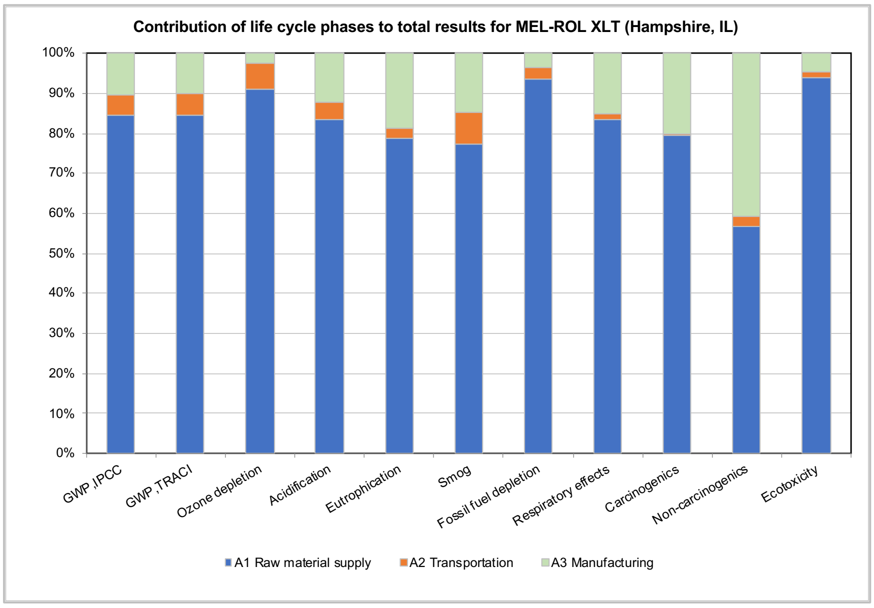

Figure 19. Contribution analysis of each impact category for MEL-ROL XLT

5.4 Sensitivity analyses

Since there were two raw materials which contributed the most to total impacts across all air and vapor barrier products evaluated, sensitivity analyses were conducted on their usage to assess the impact of decreasing their presence in those products. Global warming and fossil fuel depletion were chosen to be evaluated since the raw material acquisition stage contributed highly to those impact categories. A MEL-ROL product was chosen to study the effects of the styrene butadiene copolymer.

5.4.1. Styrene butadiene copolymer

A sensitivity analysis on MEL-ROL 60 Mil assessed a 10% reduction in the mass of styrene-butadiene copolymer present in the product. The results are presented in Table 84.

Table 84. Sensitivity analysis decreased styrene butadiene copolymer

MEL-ROL 60 mil	Global warming		Fossil fuel depletion	
	kg CO_2 eq emissions	% change	MJ surplus	% change
Baseline	1.85E+00	-	6.14E+00	-
10% decrease in styrene butadiene copolymer	1.80E+02	-2.87%	5.95E+00	-3.17%

The results indicate that the decrease in this raw material could reduce global warming potential by 2.87% and fuel depletion by 3.17%, which shows that the products are relatively not as sensitive to changes in the amount of styrene butadiene copolymer present in the products.

5.5 Overview of relevant findings

This study assessed a range of inventory and environmental indicators for W. R. MEADOWS air barrier and water resistive products. Across most impact categories for all product types, the primary finding was that the raw material acquisition stage was responsible for much of the impacts within each impact category.

The manufacturing stage was typically the second-largest contributor for all products, particularly to the carcinogenics and non-carcinogenics categories for the AIR-SHIELD and MEL-ROL products. For products like AIR-SHIELD LOW TEMP and MEL-ROL LOW TEMP, manufacturing accounted for nearly half of the GWP due to the final product packaging needed and a somewhat higher energy requirement for production.

For most products, the least significant contributor is transportation, where the weight of the raw materials and the distance traveled via truck to the manufacturing facility accounts for less than 20% of the total impacts across all categories except for the Fort Worth, TX facility, where transportation accounted for closer to 25% for some impact categories.

5.6 Conclusions and recommendations

The goal of this study was to perform a cradle-to-gate life cycle assessment (LCA) on W. R. MEADOWS' AIR-SHIELD, and MEL-ROL products to develop Transparency Reports [EPDs]™. The creation of these Transparency Reports [EPDs]™ will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose.

Overall, the study found that environmental performance is primarily driven by the raw material supply phase, which accounts for the majority total impacts across most TRACI 2.1 categories. The manufacturing stage was the second-highest contributor, and transportation played a more minor role.

Variations in impact distributions reflect the differences in product thickness, material composition, and energy demands during production. However, with the raw material acquisition stage generally being the most impactful, the greatest opportunity for improving the environmental performance of these products lies in focusing on the most impactful raw materials. Efforts can focus on sourcing more sustainable alternatives to the styrene butadiene copolymer and linear low density polyethylene (LLDPE) resin, working with suppliers to explore low-carbon alternatives. Especially with the LLDPE resin, small changes in formulation which reduce the reliance on this raw material could make relatively large reductions in total results.

Improving energy efficiency in manufacturing could further reduce impacts, particularly for products like MEL-ROL LOW TEMP where manufacturing accounts for a larger share of the potential impacts. Implementing a higher amount of renewable energy at the production facilities could contribute to emissions reductions. In addition, beginning a formal packaging takeback program could greatly reduce the amount of final product packaging needed, thereby also reducing potential impacts in this stage.

While transportation was the smallest contributor, identifying additional local sources for the Fort Worth, TX facility supply chain would help reduce the potential impacts for products made at that location.

For future LCA updates, it is recommended that W. R. MEADOWS considers collecting supplier-specific data for key materials such as the styrene butadiene copolymer and the LLDPE resin to improve the accuracy and precision of upstream data. This may help refine the LCA and track improvements over time.

Additionally, regular updates to this LCA and the associated Transparency Reports [EPDs]™ would enable high-quality year-over-year comparisons and serve as the basis for a potential optimized EPD, which is assigned a higher credit value under the Materials and Resources category in LEED and would help those looking to increase the performance of their building projects. A post-study review may provide opportunities for improving the data collection process in future years and for continuing to align with the W. R. MEADOWS goals for sustainability.

6 REFERENCES

[1] ISO 14025, “Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures”, ISO14025:2006

[2] ISO 14044:2006/Amd1:2017/Amd2:2020, “Environmental management - Life cycle assessment - Requirements and guidelines”, ISO14044:2006.

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Acronyms

BOM	Bill of materials
IGU	Insulating glass unit
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
MND	Module Not Declared
PCR	Product Category Rule document
TR	Transparency Report [EPD]™

Glossary

For the purposes of this report, the terms and definitions given in ISO 14020, ISO 14025, the ISO 14040 series, and ISO 21930 apply. The most important ones are included here:

Allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems
Close loop & open loop	A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
Cradle to grave	Addresses the environmental aspects and potential environmental impacts (e.g., use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life
Cradle to gate	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process (“gate of the factory”). It may also include transportation until use phase
Declared unit	Quantity of a product for use as a reference unit in an EPD based on one or more information modules
Functional unit	Quantified performance of a product system for use as a reference unit
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal
Life cycle assessment - LCA	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
Life cycle impact assessment - LCIA	Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product
Life cycle inventory - LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle
Life cycle interpretation	Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

APPENDIX

- [redacted]
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