LIFE CYCLE ASSESSMENT (LCA) OF BLUE RIDGE FIBERBOARD INC. SOUNDSTOP® & IBP FIBERBOARD PANEL, STRUCTODEK® HD ROOFING INSULATION BOARD, PREMIUM INSULATING SHEATHING, CANT STRIP AND TAPERED EDGE

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Authors: Luyi Huang, Sustainable Minds
Kim Hammer, Sustainable Minds

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1 INTRODUCTION

1.1 Opportunity

BLUE RIDGE FIBERBOARD, INC. specializes in producing roofing, sheathing, soundproofing, and industrial panel products for residential, commercial, and roofing applications. Operating as a subsidiary of W. R. MEADOWS, its key products include Structodek HD roofing insulation board, SoundStop & IBP fiberboard panels, Premium Insulating Sheathing, and Cant Strip and Tapered Edge.

W. R. MEADOWS, a well-established manufacturer in the concrete construction industry, offers a broad spectrum of products ranging 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, with the company continually integrating innovative and resource-efficient strategies into its processes and product offerings.

In response to growing demand for transparency in the construction industry and to uphold its internal sustainability commitments, W. R. MEADOWS has embarked on an initiative to better understand the environmental impacts of its product lines. 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 its Danville, VA facility, W. R. MEADOWS aims to assess the potential environmental impacts of BLUE RIDGE FIBERBOARD products. This comprehensive 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 SoundStop & IBP fiberboard panels, Structodek HD roofing insulation board, Premium Insulating Sheathing, and Cant Strip and Tapered Edge. These TRs are ISO 14025 Type III [1] environmental declarations that can be used for communication with and amongst other companies, architects, and consumers, and that 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 14040/44 [2], ISO 21930:2017 [3], and the UL's PCR Part A [4] and Part B: Structural and Architectural Wood Products EPD Requirements [5].

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 14044 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.

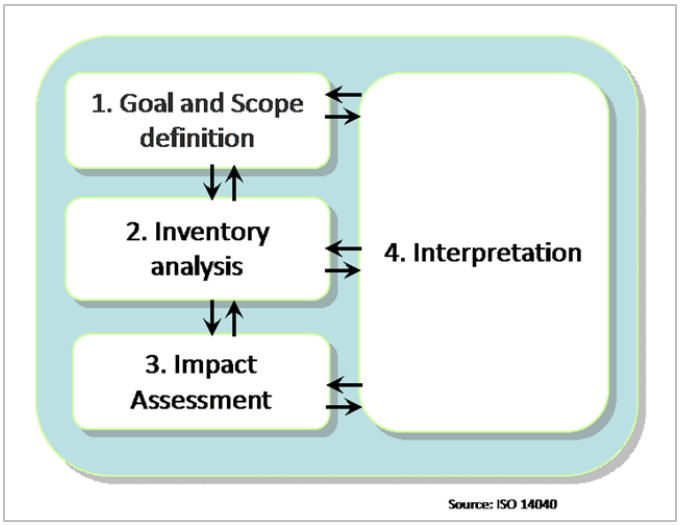


Figure 1. Phases of an LCA

- **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, company's manufacturing operations, and downstream processes (after 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 an LCA software like SimaPro, GaBi, openLCA, or others using suitable background data sets available on 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 environmental performance of the product, 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 as outlined in ISO 21930 Section 7.1.1and 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 ISO 14025 Type III environmental declarations. Both are included in this project.

1.3 Team

This LCA report is the outcome of efforts of the project team led by Kimberly A. Lombardozzi and Mark Custer on behalf of W. R. MEADOWS and BLUE RIDGE FIBERBOARD. 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 Danville, VA manufacturing facility. 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 BLUE RIDGE FIBERBOARD TRs and was evaluated for conformance to the PCRs 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 SoundStop & IBP fiberboard panels, Structodek HD roofing insulation board, Premium Insulating Sheathing, and Cant Strip and Tapered Edge. 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 fiberboards manufactured by BLUE RIDGE FIBERBOARD, a subsidiary of W. R. MEADOWS, located in Danville, VA, USA. These fiberboards can be used as roof insulation cover board with primed red and black coatings, sound reduction, and insulating sheathing, whereas roofing strips and edges can be used to provide a smooth transition from horizontal to vertical surfaces or from lower to higher elevations in a roof system. The products considered in this declaration are in different product categories under the list prescribed by the UL Part B: Structural and Architectural Wood Products EPD Requirements [5].

The BLUE RIDGE FIBERBOARD products are made with 75% post-industrial wood chips processed into cellulose fibers. Fiberboard manufacturing begins with stored wood chips, allowing moisture content and physical properties to stabilize before processing. The chips are then mechanically refined into wood fibers. These raw wood fibers are then mixed with reclaimed fibers and processed to the correct consistency. During the processing, additional materials [redacted] are added before the mat or sheet is formed. [redacted] After drying, the mats are cut to the finished fiberboard panel size. [redacted]

SoundStop is a cellulose fiberboard designed for reducing airborne noise. It absorbs airborne sound vibration by taking the shock or sound vibrations that travel through drywall and stopping the movement of the sound or shock to the other side. It can be applied to walls, ceilings, and floors to increase sound transmission class (STC) and outside inside transmission class (OITC). It can be used in homes and commercial buildings where airborne noise and sound transmission from room to room need to be eliminated. SoundStop is installed

behind gypsum drywall in interior wall and ceiling applications, or between two layers of subfloor in floor applications. Industrial Board Plain (IBP) is a utility panel which can be used for many purposes including packaging, protective sheets, fire training, and air fresheners. [redacted]

Structodek HD with Primed Red or Black Coating, herein referred to as Structodek HD, is a non-asphaltic fiberboard for roofing. It can be used as an insulation board, cover board, or re-roof/recover board. The product is a high-density roofing board designed for low-slope single-ply as well as traditional roof system applications. The coating enhances adhesion with single-ply membranes like PVC, TPO, EPDM, and CSPE. It is compatible with low VOC, water-based, foam, and traditional adhesives. It supports peel-and-stick and BUR systems with proprietary coating, minimizing adhesive absorption and ensuring strong bonds. Moisture-resistant components protect edges during use and cutting. It provides sound-deadening and thermal insulation (R-value of 1.3 per ½"). Its compressive strength is 25 psi at 10% deformation. Panels are fiberglass-free, easy to cut, and come in 4'x4' or 4'x8' sizes.

Premium Insulating Sheathing is a fiberboard made from 2% reclaimed fibers within the BLUE RIDGE FIBERBOARD manufacturing processes, designed for external wall applications. It offers improved thermal insulation while the material allows trapped moisture to escape, reducing the risk of mold. It meets ASTM C208 and C846 standards and complies with national and local building codes.

Cant Strip and Tapered Edge are low-slope roofing components made using BLUE RIDGE FIBERBOARD's Structodek HD insulation board as the starting material, cut into different shapes. Cant Strips provide a 45-degree angle transition between horizontal and vertical surfaces. Tapered Edge is designed to slope from zero to ½" or more. The design facilitates drainage and reduces ponding water. Both are compatible with most conventional roof systems. Both products offer a high R-value and can contribute to LEED credits.

BLUE RIDGE FIBERBOARD SoundStop & IBP fiberboard panels, Structodek HD roofing insulation board, Premium Insulating Sheathing, and Cant Strip and Tapered Edge are utilized for solutions between the building interior and exterior as presented in Figure 2. Table 1 lists the product information in accordance with the PCR, including the declaration name, products included in the declaration, CSI MasterFormat® classification, manufacturing location, and the type of declaration.

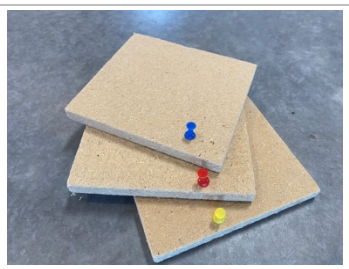
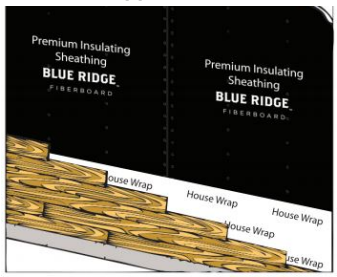
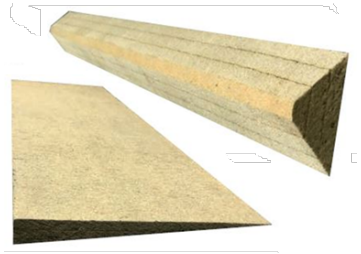
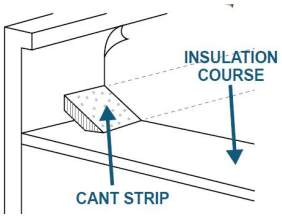
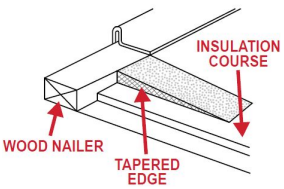
SoundStop	**Supplied product** 	**Product in application** 
IBP		
Structodek HD	**Supplied product** 	**Product in application** 
Premium Insulating Sheathing	**Supplied product** 	**Product in application** 
Cant Strip and Tapered Edge	**Supplied product** 	**Product in application**  

Figure 2. Visual representation of evaluated products and their applications

Table 1. Declared product information and type of declaration

Transparency Report [EPD]™ name	Product name	CSI MasterFormat®	Manufacturing location(s)	Type of declaration
BLUE RIDGE FIBERBOARD SoundStop	SoundStop	09 81 13	Danville, VA	Product-specific, plant-specific declaration for one manufacturer
BLUE RIDGE FIBERBOARD IBP	IBP	06 00 00 10 00 00		
BLUE RIDGE FIBERBOARD Structodek HD	Structodek HD	07 22 16		
BLUE RIDGE FIBERBOARD Premium Insulating Sheathing	Premium Insulating Sheathing	06 16 13		
BLUE RIDGE FIBERBOARD Cant Strip and Tapered Edge	Cant Strip and Tapered Edge	07 22 00		

Table 2 summarizes the applicable product specifications for each product.

Table 2. Other product information

Product name	Product specifications
SoundStop	• Panel size: 4’0” (1,200 mm) x 8’0” (2,400 mm) or 9’0” (2,700 mm) x ½” (13 mm) • Conforms to ASTM C208, Type 1 sound deadening board specifications • Thickness: ½” +/-10% • Density: 15-18 pcf (240-288 kg/m³) • Thermal Conductivity (k) max.: 0.38 Btu/h·ft²·°F (0.055 W/m·K) • Tensile Strength (parallel to surface): 150 psi (1,034 kPa) • Tensile Strength (perpendicular to surface): 600 psf (28.7 kPa) • Water Absorption by Volume, max percent; ASTM C209 (2-hour test): 7% • Expansion, 50 to 90% relative humidity, max.: 0.5% • Vapor Permeance, 39 perms or grains/hr.ft2.in. Hg (2110 ng/Pa·s.m²) • Flammability (per NFPA rating): 1 or slight • R-Value: 1.3 h·ft²·°F/Btu (0.23 K·m²/W) • Sound Transmission Class (STC): 23 • Moisture content by weight, max.: 10% • Flame Spread, ASTM E84, Class C, Flame Spread Index (FSI) 85, Smoke Developed Index 65 • Resistance to Mold Growth, ASTM D3273, highest resistance rating of 10, no visible growth • UNSPSC: 14121505
IBP	• Panel size: 4’0” (1,200 mm) x 8’0” (2,400 mm) or 9’0” (2,700 mm) x ½” (13 mm) • Thickness: ½” +/-10% • Density: 15-18 pcf (240-288 kg/m³) • Vapor Permeance, 39 perms or grains/hr.ft2.in. Hg (2110 ng/Pa·s.m²) • Moisture content by weight, max.: 10% • UNSPSC: 14121505
Structodek HD	• Nominal product thickness (inches): ½” (12.75 mm) • Density: 16.5-16.8 pcf (264-269 kg/m³) • R-value: 1.3 • Maximum flute span: 1 5/8” (40 mm) • Board dimensions: 4’x4’, 4’x8’ • Weight per square foot (lb/ft2): 0.7 • Water Absorption, ASTM C209: 7% Volume Max. • Linear Expansion, ASTM C209: 0.5% Max. • Compressive Strength @ 10% Deformation, ASTM C165: 25 psi • Compressive Strength @ 20% Deformation, ASTM C165: 62 psi • UNSPSC: 14121505
Premium Insulating Sheathing	• Panel size: 4’0” (1,200 mm) x 8’0” (2,400 mm) or 9’0” (2,700 mm) x ½” (13 mm) • Transverse Strength, lbf (N): 14 lbf (62.3 N) min • Modulus of Rupture, psi (kPa): 275 psi (1,896 kPa) min • Deflection at Specified Minimum Load, in. (mm): 0.75 in. (19 mm) • Thermal Conductivity, Btu·in./h·ft²·°F (W/m·K): 0.40 Btu·in./h·ft²·°F (0.058 W/m·K) max. • Tensile Strength Perpendicular to Surface, lbf/ft² (kPa): 600 lbf/ft² (28.7 kPa) min. • Tensile Strength Parallel to Surface, lbf/in² (kPa): 150 lbf/in² (1,034 kPa) min. • Water Absorption by Volume, %: 7% max. • Vapor Permeance, grains/h·ft²·in. Hg (mg/s·m²·kPa): 5 grains/h·ft²·in. Hg (0.287 mg/s·m²·kPa) • Moisture Content by Weight, %: 10% max. • Linear Expansion, %: 0.5 % max. • Weight per square foot: 0.70 lbs (0.317 kg) • R-value: 1.3 at ½” (13 mm) thickness • Density: 14 to 20 lb/ft³ (225 - 320 kg/m³) • UNSPSC: 30103604
Cant Strip and Tapered Edge	• ASTM C 208, Type II - Roof insulation board • Strip length: 4’0” (1,200 mm) • Water Absorption, ASTM C209: ≤10% • Transverse Strength @ 1.5, ASTM C209: 24 lbf • Tensile Strength (perpendicular to surface), ASTM C209: 500 lb/ft^2 • Density, ASTM D1037: 14-16 pcf (224-256 kg/m³) • R-value @ 1.5” thickness, ASTM C518: 3.5 h-ft^2-°F/Btu

For more information about the BLUE RIDGE FIBERBOARD products, including details about the materials that conform to the relevant standards, visit the links below:

- SoundStop & IBP: https://www.blueridgefiberboard.com/soundstop-maximize-sound-deadening/
- Structodek HD: https://www.blueridgefiberboard.com/structodek-hd-primed-red-coating-fiberboard-roof-insulation/

- Premium Insulating Sheathing: https://www.blueridgefiberboard.com/premium-insulating-sheathing-energy-saving-r-values/
- Cant Strip and Tapered Edge: https://www.blueridgefiberboard.com/cant-strip-tapered-edge-smoothes-roof-drainage-slope/

2.3 Declared unit

This LCA covers the cradle-to-gate life cycle stage for BLUE RIDGE FIBERBOARD cellulose fiberboard products. According to the PCR, the declared unit for panel products is one cubic meter (1 m^3), and the declared unit for moulding products in one meter (1 m). Table 3 lists the declared unit properties for each product.

Table 3. Declared unit properties

Name	SoundStop & IBP	Structodek HD	Premium Insulating Sheathing	Cant Strip and Tapered Edge
Declared unit	1m^3	1m^3	1m^3	1m
Mass (kg)	254	266	265	0.693
Conversion to cubic meter from a meter square (m^2) at ½" (12.75 mm) thickness	78.7	78.7	78.7	-
Thickness to achieve declared unit (m)	78.7 individual 1m^2 panels at ½" (12.7 mm) thickness	78.7 individual 1m^2 panels at ½" (12.7 mm) thickness	78.7 individual 1m^2 panels at ½" (12.7 mm) thickness	½" (12.7 mm)
Density (kg/m^3)	254	266	265	266
Moisture content %	10% max	0.5% max	10% max	0.5% max

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			CONSTRUC-TION 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 w ater 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, manufacturing, and final assembly for both the product and its associated packaging. Table 4 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 4. System boundary inclusions and exclusions

Included	Excluded
• Raw material extraction for components • Packaging of raw materials and their disposal • Transport of raw materials from extraction/production to manufacturing location of components • Other inputs to the factory and internal transport • Processing of raw materials into components • Energy production • Transport of components to assembly locations • Manufacturing scrap and its disposal • Packaging associated with the final product • Manufacture and transport of packaging materials associated with the final product • Disposal of final packaging materials associated with the final products (A5)	• Construction of major capital equipment • Manufacturing of support 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

II. **Transport to factory (A2)**
   - Transportation of components to the W. R. MEADOWS 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. 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 W. R. MEADOWS and the plant manager from BLUE RIDGE FIBERBOARD. Twelve months of data (CY2023) was collected at the W. R. MEADOWS facility in Danville, VA. 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 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 the W. R. MEADOWS's control. If direct measurements were not available, 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.

BLUE RIDGE FIBERBOARD and W. R. MEADOWS provided the full bills of material (BOMs) with a detailed breakdown of the raw materials mass percentage for each product, as summarized in Table 5 and Table 6. The BLUE RIDGE FIBDERBOARD panels are comprised of approximately 80-85% wood chips and 15-20% of starch, paraffin, clay, and other additives, all on an oven-dry or 100% solids basis weight. Waste and scrap created during raw material manufacturing and the emissions associated with transporting waste and scrap to the point of disposal were included in the background data sets used to model the raw materials. None of these products contain hazardous substances according to the standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C or materials characterized as hazardous by the TRI.

Raw materials are extracted and manufactured by material suppliers. The supplied wood chips are comprised of 75% post-industrial wood, sourced from sawmill waste including but not limited to sawdust, bark, chips, slabs, and cuttings from lumber or timber. All products contain approximately 2% of reclaimed fibers from the BLUE RIDGE FIBERBOARD manufacturing process. [redacted]

Table 5. BLUE RIDGE FIBERBOARD product raw material composition

Raw material	SoundStop & IBP	Structodek HD	Premium Insulating Sheathing	Cant Strip and Tapered Edge
Cellulose, pulp	80-86%	80-85%	80-85%	80-85%
Starch	5-8%	8-10%	8-10%	8-10%
Paraffin	2-5%	2-5%	2-5%	2-5%
Water	2-5%	2-5%	2-5%	2-5%
Aluminum sulfate	1-2%	1-2%	1-2%	1-2%
Clay	-	1-2%	<1%	1-2%
Sodium aluminate	<1%	<1%	<1%	<1%
Pigment	-	<1%	<1%	<1%
Total	100%	100%	100%	100%

Table 6. BLUE RIDGE FIBERBOARD product raw material composition per declared unit

Raw material	SoundStop & IBP	Structodek HD	Premium Insulating Sheathing	Cant Strip and Tapered Edge
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total (kg)	**253.58**	**265.88**	**260.66**	**0.69**

Suppliers transport raw materials to the W. R. MEADOWS's manufacturing plant. All ingredients sourced in North America are transported by either 24T truck & trailer or 25T truck & trailer. The materials were assumed to come directly from the supplier and not go through a distribution center. Transportation modes and distances for each of the raw materials supplied are provided in Table 7. Transportation for wood chips was calculated to include both virgin and post-industrial wood chips. Table 8 reflects the combined transportation and mass per declared unit for each product.

Table 7. Raw material supplier transportation modes and distances by material

Raw material	Road distance (miles)	Means of transportation
Cellulose, pulp	[redacted]	Truck & trailer, 24t
Starch	[redacted]	Truck & trailer, 25t
Paraffin	[redacted]	Truck & trailer, 22t
Aluminum sulfate	[redacted]	Truck & trailer, 24t
Sodium aluminate	[redacted]	Truck & trailer, 22t
Clay	[redacted]	Truck & trailer, 24t
Pigment	[redacted]	Truck & trailer, 25t
Water	City water pipeline	Utility piping

Table 8. Raw material supplier transportation modes and distances per declared unit

Means of transportation	SoundStop & IBP	Structodek HD	Premium Insulating Sheathing	Cant Strip and Tapered Edge
Truck & trailer	[redacted]	[redacted]	[redacted]	[redacted]

3.2.2. Manufacturing (A3)

The fiberboard manufacturing process starts with wood chips, which have been stored for eight weeks. The storage period ensures that the chips' moisture content and physical properties stabilize before further processing. After storage, the wood chips undergo mechanical refining, breaking into wood fibers. These refined fibers are then combined with reclaimed fibers to produce a mixture with a specific consistency required for subsequent steps.

During the processing phase, several additives are introduced to the fiber mixture. [redacted] These materials are mixed thoroughly to achieve a uniform distribution before the next stage.

The processed fiber mixture is then formed into a continuous mat or sheet using a fourdrinier machine. This step involves dewatering the fiber slurry to remove excess water and pressing it under a vacuum to achieve the desired density and uniformity. Once the sheet is formed, it is cut into large mats for further processing. These mats are loaded into a dryer, where moisture is removed through controlled heating. This drying stage is essential to reduce the moisture content to the required level, ensuring dimensional stability and preparing the mats for the final cutting phase.

After drying, the mats are cut to size to meet the specifications for fiberboard panels. The panels are then packaged for distribution and stored until they are ready to be transported to their intended destinations.

Cant Strip and Tapered Edge are additionally sent to an external manufacturer for cutting into the final profiles. After the converters process the pieces, they are transported back to the BLUE RIDGE FIBERBOARD facility.

The primary manufacturing process incorporates new and reclaimed fibers to optimize raw material usage and reduce waste. The integration of reclaimed fibers minimizes the reliance on virgin raw materials and enhances material efficiency. The stages of mechanical refining and drying are energy-intensive and require careful management to ensure operational efficiency. The introduction of additives is tightly controlled to ensure consistent quality in the finished panels. Off-cuts generated during the cutting phase are recycled back into the production stream, reducing material waste. This manufacturing approach focuses on creating a functional product while adhering to principles of resource efficiency and waste minimization. Each stage in the process is designed to ensure consistency, reliability, and adherence to quality standards, resulting in fiberboard panels that meet specifications.

All fines generated during the screening of wood chips, which include saw dust, bark, and dirt, are assumed to be 100% landfilled. Wastewater is included in the model. The amount of wastewater includes plant process water overflow from BLUE RIDGE FIBERBOARD, untreated sanitary sewage, and rainwater. The destination of the wastewater output from the manufacturing process is municipal wastewater treatment. Solid waste and scrap board are transported by truck to a

landfill site 8.4 miles (13.5 km) from the BLUE RIDGE FIBERBOARD facility. Per ISO 21930, 2.8.4.1.2, the useable output flows such as steel scrap are not considered co-products but are considered waste, and no allocation to secondary material, secondary fuels, or recovered energy is applied.

Table 9 and Table 10 present the manufacturing inputs needed and outputs generated for one declared unit of product. Table 11 and Table 12 show the emissions to air and water, respectively, per declared unit.

Table 9. BLUE RIDGE FIBERBOARD product manufacturing inputs per declared unit

Product	Electricity (kWh)	Natural gas (m3)	Water (gal)	Packaging (poly bags) (kg)
SoundStop & IBP	[redacted]	[redacted]	[redacted]	[redacted]
Structodek HD	[redacted]	[redacted]	[redacted]	[redacted]
Premium Insulating Sheathing	[redacted]	[redacted]	[redacted]	[redacted]
Cant Strip & Tapered Edge	[redacted]	[redacted]	[redacted]	[redacted]

Table 10. BLUE RIDGE FIBERBOARD product manufacturing outputs per declared unit

Product	Waste collection transport (lbmi)	Landfill disposal- solid waste and scrap boards (kg)	Waste Water (gal)
SoundStop & IBP	[redacted]	[redacted]	[redacted]
Structodek HD	[redacted]	[redacted]	[redacted]
Premium Insulating Sheathing	[redacted]	[redacted]	[redacted]
Cant Strip & Tapered Edge	[redacted]	[redacted]	[redacted]

Table 11. BLUE RIDGE FIBERBOARD product manufacturing emissions to air per declared unit

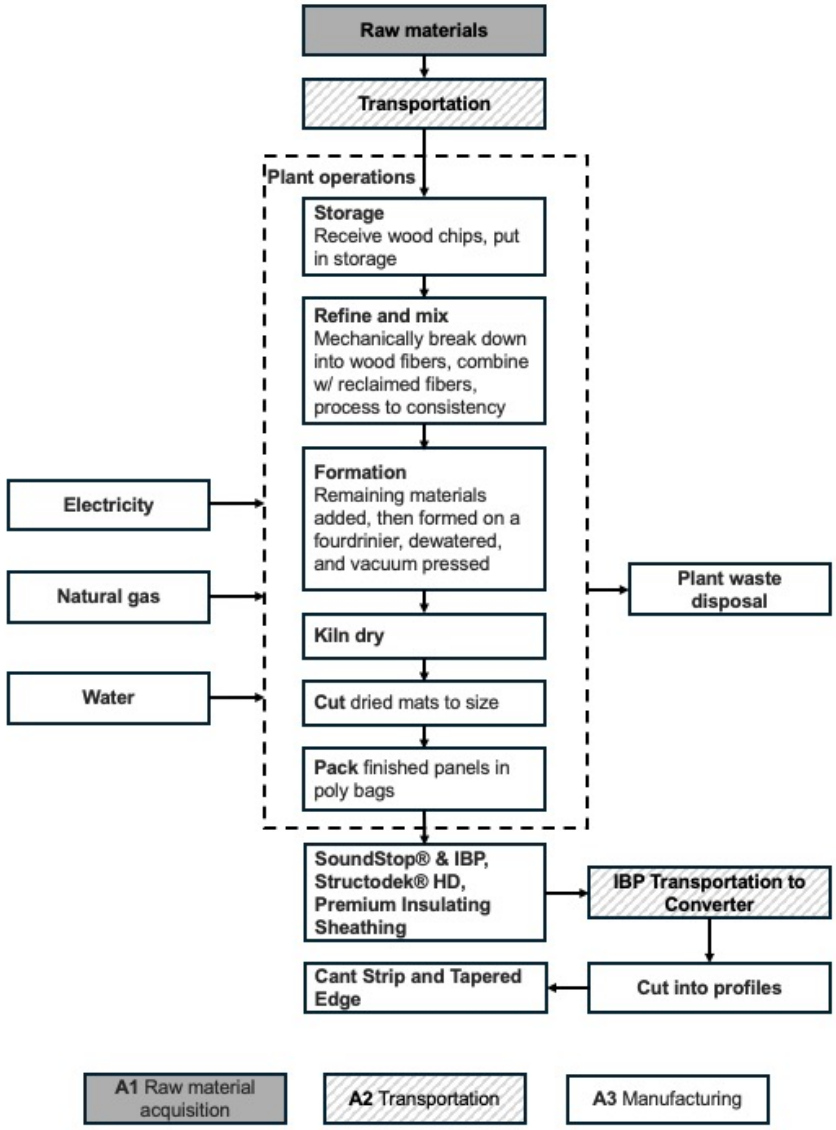
Product	Volatile organic compounds (kg)	Sulfur dioxides (kg)	Particulate matter (kg)	Carbon monoxide (kg)	Nitrogen dioxide (kg)
SoundStop & IBP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Structodek HD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Premium Insulating Sheathing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cant Strip & Tapered Edge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 12. BLUE RIDGE FIBERBOARD product manufacturing emissions to water per declared unit

Product(s)	Ammonia (kg)
SoundStop & IBP	[redacted]
Structodek HD	[redacted]
Premium Insulating Sheathing	[redacted]
Cant Strip & Tapered Edge	[redacted]

Figure 4 illustrates the cradle-to-gate system process flow diagram for W. R. MEADOWS BLUE RIDGE FIBERBOARD SoundStop & IBP fiberboard panels, Structodek HD roofing insulation board, Premium Insulating Sheathing, and Cant Strip and Tapered Edge products. This study has included all upstream energy and material flows related to production.

Figure 4. System boundary and product flow diagram for BLUE RIDGE FIBERBOARD product manufacturing



3.2.3. Additional information for biogenic carbon disclosure

This section discloses the biogenic carbon emissions associated with the final product disposal stage (C4). While the impacts from installation and product disposal are out of the scope of this cradle-to-gate study, ISO 21930:2017 requires that biogenic carbon emissions associated with packaging disposed after product installation and the biogenic carbon content of products disposed are separately reported.

The biogenic carbon removals from products in the raw material supply stage (A1) are later accounted for as biogenic carbon emissions from the products in the disposal stage (C4). The biogenic carbon emissions from products are detailed in Table 13.

Table 13. Biogenic carbon disclosure for the BLUE RIDGE FIBERBOARD products per declared unit

Product	Unit	C4
SoundStop & IBP		
Biogenic carbon emissions from product	kg CO_2	3.54E+01
Structodek HD		
Biogenic carbon emissions from product	kg CO_2	3.58E+01
Premium Insulating Sheathing		
Biogenic carbon emissions from product	kg CO_2	3.52E+01
Cant Strip and Tapered Edge		
Biogenic carbon emissions from product	kg CO_2	1.13E-01

3.3 Background data

This section details the background data sets used for modeling all relevant activities associated with the cradle-to-gate life cycle of the BLUE RIDGE FIBERBOARD 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

Data representing upstream and downstream raw materials were obtained from the ecoinvent v3.10 and US-EI 2.2 databases. Table 14 lists the most relevant LCI data sets used in modeling the raw materials.

Table 14. Key material data sets used in inventory analysis

Raw material	Data set	Database	Technology	Reference year	Geography
Wood chips (post-industrial)	*Empty data set representing post-industrial recycled content*				
Wood chips	Wood chips, dry, measured as dry mass {RoW}| market for wood chips, dry, measured as dry mass | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Starch	Potato starch {RoW}| potato starch production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2023	Rest of World (non-Europe)
Paraffin	Paraffin {RoW}| paraffin production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Aluminum sulfate	Ammonium sulfate {RoW}| market for ammonium sulfate | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Sodium aluminate	Sodium aluminate, powder {GLO}| market for sodium aluminate, powder | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
Clay	Kaolin {RoW}| kaolin production | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Pigment	Carbon black {GLO}| market for carbon black | Cut-off, U *(proxy)*	ecoinvent v3.10	Appropriate technology	2024	Global (GLO)
Water	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	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 15 shows the most relevant LCI data sets used in modeling transportation.

Table 15. Transportation data set used in inventory analysis

Vehicle type	Data set	Database	Technology	Reference year	Geography
Semi-truck	Transport, freight, lorry 16-32 metric ton, EURO6 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	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 Danville, VA. The grid mix used was the most recent from eGRID for the SRVC subregion. Table 16 shows the most relevant LCI data sets used in modeling fuels and energy.

Table 16. Key energy data sets used in inventory analysis

Energy source	Data set	Database	Technology	Reference year	Geography
Electricity	Electricity mix, eGrid subregion, SRVC/US U	LCA Commons	Appropriate technology	2023	United States
Natural gas	Heat, district or industrial, natural gas {RoW}| market for heat, district or industrial, natural gas | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Water	Tap water {RoW}| market for tap water | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)

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 17 lists the relevant disposal data sets used in the model.

Table 17. Key disposal data sets used in inventory analysis

Disposal activity	Data set	Database	Technology	Reference year	Geography
Landfill of solid waste	Municipal solid waste {RoW}| treatment of municipal solid waste, sanitary landfill | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Landfill of scrap boards	Waste wood, untreated {RoW}| treatment of waste wood, untreated, sanitary landfill | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Wastewater treatment	Wastewater from soft fibreboard production {RoW}| treatment of wastewater from soft fibreboard production, wastewater treatment | Cut-off, U	ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)
Road transport for collecting municipal waste	Municipal waste collection service by 21 metric ton lorry {RoW}| municipal waste collection service by 21 metric ton lorry | Cut-off, U	Ecoinvent v3.10	Appropriate technology	2024	Rest of World (non-Europe)

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. No known mass flow has been omitted in this study.
- 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. No known mass or energy flow has been omitted in this study.
- 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). No known mass flow has been omitted in this study.

In this report, no known flows are deliberately excluded; 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 the modeling of the LCA.

The W. R. MEADOWS BLUE RIDGE FIBERBOARD facility produces multiple types of panel 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 panel 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.

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.

For recycled content, system boundaries were drawn consistent with the cut-off allocation approach. Post-industrial wood chips, which are used as an input into some of the included production processes, are assumed to enter the system burden-free in that burden associated with the production of virgin wood chips is not allocated to the fiberboard life cycle.

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 W. R. MEADOWS 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 Isolatek 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 [6] (see Table 18). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [7]. 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 18. 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 the wood chips used in the product. 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 time 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 [8] and weighting [9] as shown in Table 19 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 [6].

Table 19. 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 American Center for Life Cycle Assessment's (ACLCA) guidance to the ISO 21930:2017 metrics [10]. The consumption of freshwater indicator, which was calculated in accordance with this guidance, is reported in compliance with ISO 14046. Use of renewable and non-renewable energy resources with energy content were calculated using the Cumulative Energy Demand (LHV) impact assessment methodology [11]. Abiotic depletion potential was calculated using the CML impact assessment methodology [12]. 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 SRVC eGRID data set, and no energy was recovered.

Hazardous and non-hazardous wastes are calculated based on the amount of waste generated during the life cycle of each product studied, mainly during the manufacturing of the products. All waste treatments in models were considered based on the real facility activities. 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. SoundStop & IBP

Table 20. Resource use and waste flows for SoundStop & IBP per declared unit (1m^3)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	4.35E+01	3.17E-02	1.08E+02	**1.51E+02**
Renewable primary resources with energy content used as material	MJ, NCV	7.21E+02	0	0	**7.21E+02**
Total use of renewable primary resources with energy content	MJ, NCV	7.65E+02	3.17E-02	1.08E+02	**8.73E+02**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	5.04E+02	2.07E+01	3.56E+03	**4.08E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.81E+02	0	0	**2.81E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	7.85E+02	2.07E+01	3.56E+03	**4.36E+03**
Secondary materials	kg	1.62E+02	0	0	**1.62E+02**
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 fresh water resources	m3	2.68E+01	2.71E-02	3.74E+00	**3.06E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	7.07E+02	1.94E+01	2.12E+03	**2.85E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	5.37E+00	4.39E-03	1.86E-01	**5.56E+00**
Non-hazardous waste disposed	kg	6.18E+01	1.78E-02	8.79E+01	**1.50E+02**
High-level radioactive waste, conditioned, to final repository	kg	1.40E-04	2.32E-07	1.64E-05	**1.56E-04**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	2.98E-04	4.54E-07	1.15E-02	**1.18E-02**
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	-3.54E+01	0	0	**-3.54E+01**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	**0**
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**

5.2.2. Structodek HD

Table 21. Resource use and waste flows for Structodek HD per declared unit (1 m^3)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	3.11E+02	1.04E-01	1.13E+02	**4.24E+02**
Renewable primary resources with energy content used as material	MJ, NCV	1.82E+03	0	0	**1.82E+03**
Total use of renewable primary resources with energy content	MJ, NCV	2.13E+03	1.04E-01	1.13E+02	**2.24E+03**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	9.65E+02	6.78E+01	3.74E+03	**4.77E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.86E+02	0	0	**2.86E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.25E+03	6.78E+01	3.74E+03	**5.06E+03**
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 fresh water resources	m3	3.08E+01	4.98E-02	3.23E+00	**3.41E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.11E+03	6.36E+01	2.23E+03	**3.41E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	7.25E+00	1.44E-02	2.02E-01	**7.47E+00**
Non-hazardous waste disposed	kg	8.25E+01	5.82E-02	9.39E+01	**1.77E+02**
High-level radioactive waste, conditioned, to final repository	kg	2.83E-04	7.60E-07	1.89E-05	**3.03E-04**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.12E-04	1.49E-06	1.21E-02	**1.27E-02**
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	-3.58E+01	0	0	**-3.58E+01**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	**0**
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**

5.2.3. Premium Insulating Sheathing

Table 22. Resource use and waste flows for Premium Insulating Sheathing per declared unit (1 m^3)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	2.65E+02	9.24E-02	1.13E+02	**3.78E+02**
Renewable primary resources with energy content used as material	MJ, NCV	1.83E+03	0	0	**1.83E+03**
Total use of renewable primary resources with energy content	MJ, NCV	2.10E+03	9.24E-02	1.13E+02	**2.21E+03**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	1.07E+03	6.03E+01	3.74E+03	**4.87E+03**
Non-renewable primary resources with energy content used as material	MJ, NCV	2.90E+02	0	0	**2.90E+02**
Total use of non-renewable primary resources with energy content	MJ, NCV	1.36E+03	6.03E+01	3.74E+03	**5.16E+03**
Secondary materials	kg	4.30E+00	0	0	**4.30E+00**
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 fresh water resources	m3	3.05E+01	4.43E-02	3.44E+00	**3.40E+01**
Abiotic depletion (fossil fuels)	MJ, LHV	1.22E+03	5.66E+01	2.23E+03	**3.51E+03**
Output flows and waste category indicators					
Hazardous waste disposed	kg	7.22E+00	1.28E-02	2.09E-01	**7.45E+00**
Non-hazardous waste disposed	kg	8.24E+01	5.18E-02	9.56E+01	**1.78E+02**
High-level radioactive waste, conditioned, to final repository	kg	2.79E-04	6.76E-07	2.07E-05	**3.00E-04**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	6.05E-04	2.94E-06	1.21E-02	**1.27E-02**
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	-3.52E+01	0	0	**-3.52E+01**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	**0**
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**

5.2.4. Cant Strip and Tapered Edge

Table 23. Resource use and waste flows for Cant Strip and Tapered Edge per declared unit (1 m)

Parameter	Unit	A1	A2	A3	Total
Resource use indicators					
Renewable primary energy used as energy carrier (fuel)	MJ, NCV	5.55E+00	2.90E-03	4.49E-03	**5.56E+00**
Renewable primary resources with energy content used as material	MJ, NCV	6.29E+00	0	0	**6.29E+00**
Total use of renewable primary resources with energy content	MJ, NCV	1.18E+01	2.90E-03	4.49E-03	**1.18E+01**
Non-renewable primary resources used as an energy carrier (fuel)	MJ, NCV	2.58E+00	1.90E+00	3.02E+00	**7.50E+00**
Non-renewable primary resources with energy content used as material	MJ, NCV	6.77E-01	0	0	**6.77E-01**
Total use of non-renewable primary resources with energy content	MJ, NCV	3.26E+00	1.90E+00	3.02E+00	**8.18E+00**
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 fresh water resources	m3	7.19E-01	1.39E-02	8.30E-02	**8.16E-01**
Abiotic depletion (fossil fuels)	MJ, LHV	2.90E+00	1.78E+00	2.70E+00	**7.38E+00**
Output flows and waste category indicators					
Hazardous waste disposed	kg	0	0	0	**0**
Non-hazardous waste disposed	kg	0	0	1.47E-02	**1.47E-02**
High-level radioactive waste, conditioned, to final repository	kg	7.37E-07	2.00E-09	2.27E-08	**7.62E-07**
Intermediate- and low-level radioactive waste, conditioned, to final repository	kg	1.59E-06	3.92E-09	6.18E-08	**1.66E-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	-1.13E-01	0	0	**-1.13E-01**
Biogenic Carbon Emission from Product	kg CO_2	0	0	0	**0**
Biogenic Carbon Removal from Packaging	kg CO_2	0	0	0	**0**
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**

Significant data limitations currently exist within the LCI data used to generate waste metrics for Life Cycle Assessments and Environmental Product Declarations. The waste metrics were calculated in a way conformant with the requirements of ISO 21930:2017, but these values represent rough estimates and are for informational purposes only. As such, no decisions regarding actual cradle-gate waste performance between products should be derived from these reported values.

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 BLUE RIDGE FIBERBOARD products. 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."*

Additionally, the impact assessment results are calculated using characterization factors published by the Intergovernmental Panel on Climate Change (IPCC) 100-year methodology: IPCC 2013 AR5 [13]. This methodology categorizes global warming potential (GWP) into $GWP_{TOTAL,}$ $GWP_{BIOGENIC}$, and GWP_{FOSSIL} to transparently report how carbon emissions captured and stored in the products and carbon emissions associated with fossil fuel usage impact the total combined GWP results. TRACI v2.1 GWP was developed using IPCC 2007 AR4 and was disclosed in the same manner for consistent reporting. EPD users shall not use additional measures for comparative purposes. All impact categories from IPCC 100-year GWP are utilized to derive comprehensive climate impact results, but it should be noted that there are known limitations due to uncertainties in emission lifetimes, carbon cycle feedbacks, and regional climate variations.

5.3.1. SoundStop & IBP

Table 24 shows the LCIA results, and Table 25 and Figure 5 show the percent contribution of each stage of the production of SoundStop & IBP. The raw material acquisition stage dominates the results for most impact categories (7 out of 11), followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of SoundStop & IBP production are 1.89E+02 kg CO_2-eq. The manufacturing stage contributed 1.51E+02 kg CO_2-eq, accounting for 79.46% of the total results. The raw material acquisition stage generated 2.00E+00 CO_2-eq, with 3.54E+01 CO_2-eq of biogenic carbon uptake from the post-consumer wood chips. The manufacturing stage was dominant for most impact categories including ozone depletion and fossil fuel depletion; however, the raw material acquisition stage has a larger contribution than the manufacturing stage in a few impact categories including notably ecotoxicity (97.9%), eutrophication (86.1%), and carcinogenics and non-carcinogenics (91-95%).

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 26). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 73.7% of the total impacts, manufacturing for 26.1%, and transportation for 0.004%.

Table 24. Life cycle impact assessment results for SoundStop & IBP per declared unit (1 m^3)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	-1.07E+00	1.46E+00	1.86E+02	**1.86E+02**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-3.54E+01	0	3.54E+01	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	3.43E+01	1.46E+00	1.51E+02	**1.86E+02**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	2.00E+00	1.44E+00	1.85E+02	**1.89E+02**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-3.54E+01	0	3.54E+01	**0**
GWP, TRACI 2.1_{FOSSIL}	kg CO_2 eq	3.74E+01	1.44E+00	1.50E+02	**1.89E+02**
Ozone depletion	kg CFC-11 eq	1.38E-06	2.23E-08	7.64E-06	**9.04E-06**
Acidification	kg SO_2 eq	4.23E-01	1.71E-03	3.27E-01	**7.51E-01**
Eutrophication	kg N eq	3.44E-01	1.25E-04	5.54E-02	**3.99E-01**
Smog	kg O_3 eq	3.32E+00	2.63E-02	3.97E+00	**7.31E+00**
Fossil fuel depletion	MJ surplus	7.51E+01	2.75E+00	2.78E+02	**3.56E+02**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	4.47E-02	4.48E-04	2.27E-02	**6.78E-02**
Carcinogenics	CTUh	91.02%	0.05%	8.93%	**100%**
Non carcinogenics	CTUh	94.47%	0.28%	5.25%	**100%**
Ecotoxicity	CTUe	97.82%	0.62%	1.56%	**100%**

Table 25. Percent contributions of each stage to each impact category for SoundStop & IBP per declared unit (1 m^3)

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	18.43%	0.78%	80.79%	**100%**
GWP, $TRACI_{2.1}$	19.77%	0.76%	79.46%	**100%**
Ozone depletion	15.26%	0.25%	84.49%	**100%**
Acidification	56.23%	0.23%	43.54%	**100%**
Eutrophication	86.09%	0.03%	13.88%	**100%**
Smog	45.38%	0.36%	54.26%	**100%**
Fossil fuel depletion	21.09%	0.77%	78.14%	**100%**
Additional environmental information				
Respiratory effects	58.37%	0.82%	40.80%	**100%**
Carcinogenics	91.02%	0.05%	8.93%	**100%**
Non-carcinogenics	94.47%	0.28%	5.25%	**100%**
Ecotoxicity	97.82%	0.62%	1.56%	**100%**

Table 26. SM millipoint scores for SoundStop & IBP per declared unit (1 m^3)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.46E+01	8.44E-02	5.26E+00	**1.99E+01**

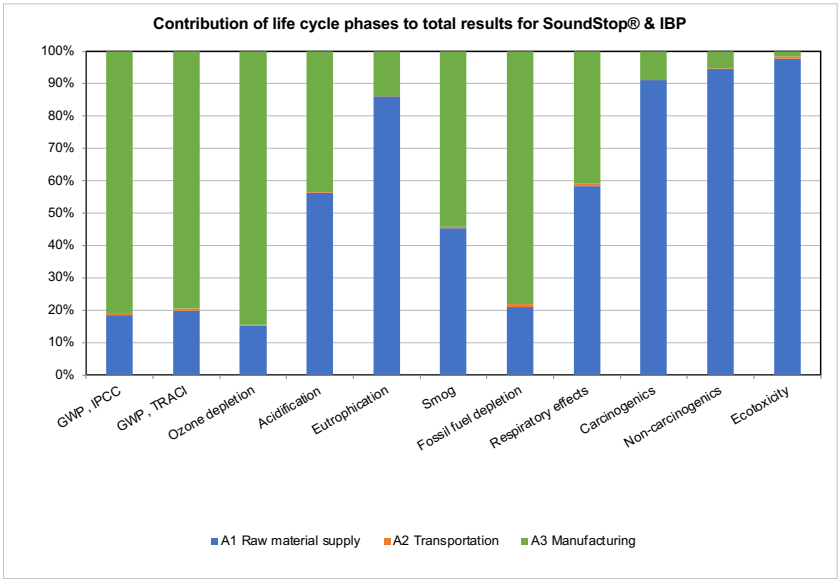


Figure 5. Contribution analysis of each impact category for SoundStop & IBP

5.3.2. Structodek HD

Table 27 shows the LCIA results, and Table 28 and Figure 6 show the percent contribution of each stage of the production of Structodek HD. The raw material acquisition stage dominates the results for most impact categories (7 out of 11), followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of Structodek HD production is 2.08E+02 kg CO_2-eq. The manufacturing stage contributed 1.58E+02 kg CO_2-eq, accounting for 75.97% of the total results The raw material acquisition stage generated 4.52E+01 CO_2-eq, accounting for 21.76%, with a biogenic carbon uptake of 3.58E+01 CO_2-eq. The manufacturing stage also dominant for most impact categories including ozone depletion and fossil fuel depletion; however, the raw material acquisition stage has a larger contribution than the manufacturing stage in a few impact categories including

notably ecotoxicity (97.1%), eutrophication (92.7%), and carcinogenics and non-carcinogenics (95-97%).

Among the raw materials used, the wood chips and starch together contribute to over 80% of the total GWP results in the raw material acquisition phase.

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 29). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 75.1% of the total impacts, manufacturing for 23.8%, and transportation for 1.2%.

Table 27. Life cycle impact assessment results for Structodek HD per declared unit (1 m^3)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	5.43E+00	4.77E+00	1.94E+02	**2.04E+02**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-3.58E+01	0	3.58E+01	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	4.12E+01	4.77E+00	1.58E+02	**2.04E+02**
GWP, TRACI 2.1$_{TOTAL}$	kg CO_2 eq	9.40E+00	4.71E+00	1.94E+02	**2.08E+02**
GWP, TRACI 2.1$_{BIOGENIC}$	kg CO_2 eq	-3.58E+01	0	3.58E+01	**0**
GWP, $TRACI_{FOSSIL}$	kg CO_2 eq	4.52E+01	4.71E+00	1.58E+02	**2.08E+02**
Ozone depletion	kg CFC-11 eq	1.74E-06	7.31E-08	8.02E-06	**9.83E-06**
Acidification	kg SO_2 eq	5.19E-01	5.60E-03	3.44E-01	**8.69E-01**
Eutrophication	kg N eq	4.41E-01	4.09E-04	3.45E-02	**4.76E-01**
Smog	kg O_3 eq	4.03E+00	8.61E-02	4.18E+00	**8.29E+00**
Fossil fuel depletion	MJ surplus	8.41E+01	9.00E+00	2.93E+02	**3.86E+02**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	3.85E-02	1.47E-03	2.34E-02	**6.34E-02**
Carcinogenics	CTUh	91.79%	0.13%	8.08%	**100%**
Non carcinogenics	CTUh	94.92%	0.73%	4.35%	**100%**
Ecotoxicity	CTUe	97.12%	1.58%	1.29%	**100%**

Table 28. Percent contributions of each stage to each impact category for Structodek HD roofing insulation board per declared unit (1 m^3)

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{FOSSIL}$	20.19%	2.33%	77.47%	**100%**
GWP, $TRACI_{2.1}$	21.76%	2.27%	75.97%	**100%**
Ozone depletion	17.69%	0.74%	81.57%	**100%**
Acidification	59.76%	0.64%	39.60%	**100%**
Eutrophication	92.67%	0.09%	7.24%	**100%**
Smog	48.60%	1.04%	50.36%	**100%**
Fossil fuel depletion	21.79%	2.33%	75.88%	**100%**
Additional environmental information				
Respiratory effects	60.72%	2.31%	36.96%	**100%**
Carcinogenics	91.79%	0.13%	8.08%	**100%**
Non-carcinogenics	94.92%	0.73%	4.35%	**100%**
Ecotoxicity	97.12%	1.58%	1.29%	**100%**

Table 29. SM millipoint scores for Structodek HD per declared unit (1 m^3)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.72E+01	2.77E-01	5.44E+00	**2.29E+01**

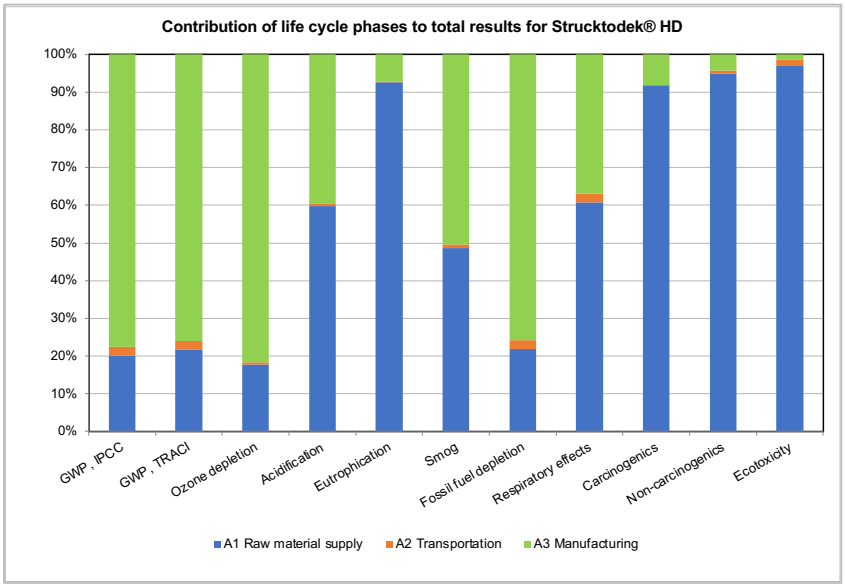


Figure 6. Contribution analysis of each impact category for Structodek HD

5.3.3. Premium Insulating Sheathing

Table 30 shows the LCIA results, and Table 31 and
Figure **7** show the percent contribution of each stage of the production of Premium Insulating Sheathing. The raw material acquisition stage dominates the results for most impact categories (7 out of 11), followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of Premium Insulating Sheathing production is 2.10E+02 kg CO_2-eq. The manufacturing stage contributed 1.58E+02 kg CO_2-eq, accounting for 75% of the total results. The raw material acquisition stage generated 4.82E+01 CO_2-eq, accounting for 22.95%, with a biogenic carbon uptake of 3.52E+01 CO_2-eq. The manufacturing stage was dominant for most impact categories including ozone depletion and fossil fuel depletion; however, the raw material acquisition stage has a larger contribution than the manufacturing in a few impact categories including notably ecotoxicity (97.43%), eutrophication (92.1%), and carcinogenics and non-carcinogenics (92.8-95.6%).

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 32). Across all 10 impact categories, the SM single-figure score indicates that raw materials acquisition accounts for around 75% of the total impacts, manufacturing for 23.8%, and transportation for 1.06%.

Table 30. Life cycle impact assessment results for Premium Insulating Sheathing per declared unit (1 m^3)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	9.19E+00	4.24E+00	1.93E+02	**2.07E+02**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-3.52E+01	0	3.52E+01	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	4.44E+01	4.24E+00	1.58E+02	**2.07E+02**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	1.30E+01	4.19E+00	1.93E+02	**2.10E+02**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-3.52E+01	0	3.52E+01	**0**
GWP, TRACI 2.1_{FOSSIL}	kg CO_2 eq	4.82E+01	4.19E+00	1.58E+02	**2.10E+02**
Ozone depletion	kg CFC-11 eq	2.33E-06	6.50E-08	8.00E-06	**1.04E-05**
Acidification	kg SO_2 eq	7.58E-01	4.98E-03	4.01E-01	**1.16E+00**
Eutrophication	kg N eq	4.73E-01	3.64E-04	4.01E-02	**5.14E-01**
Smog	kg O_3 eq	9.12E+00	7.66E-02	5.55E+00	**1.47E+01**
Fossil fuel depletion	MJ surplus	1.38E+02	8.01E+00	2.93E+02	**4.39E+02**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	9.21E-02	1.31E-03	2.42E-02	**1.18E-01**
Carcinogenics	CTUh	92.8%	0.1057%	7.11%	**100%**
Non carcinogenics	CTUh	95.6%	0.57%	3.81%	**100%**
Ecotoxicity	CTUe	97.4%	1.33%	1.23%	**100%**

Table 31. Percent contributions of each stage to each impact category for Premium Insulating Sheathing per declared unit (1 m^3)

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{BIOGENIC}$	21.46%	2.05%	76.48%	**100%**
GWP, $TRACI_{2.1}$	22.95%	2.00%	75.06%	**100%**
Ozone depletion	22.43%	0.63%	76.95%	**100%**
Acidification	65.11%	0.43%	34.47%	**100%**
Eutrophication	92.12%	0.07%	7.81%	**100%**
Smog	61.87%	0.52%	37.61%	**100%**
Fossil fuel depletion	31.42%	1.83%	66.75%	**100%**
Additional environmental information				
Respiratory effects	78.32%	1.11%	20.57%	**100%**
Carcinogenics	92.78%	0.11%	7.11%	**100%**
Non-carcinogenics	95.62%	0.57%	3.81%	**100%**
Ecotoxicity	97.43%	1.33%	1.23%	**100%**

Table 32. SM millipoint scores for Premium Insulating Sheathing per declared unit (1 m^3)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	1.74E+01	2.46E-01	5.53E+00	**2.32E+01**

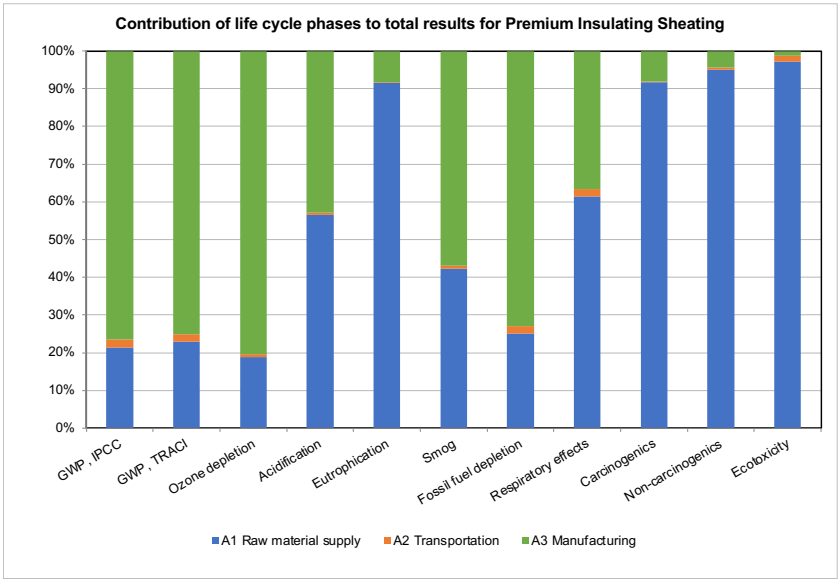


Figure 7. Contribution analysis of each impact category for Premium Insulating Sheathing

5.3.4. Cant Strip and Tapered Edge

Table 33 shows the LCIA results, and Table 34 and

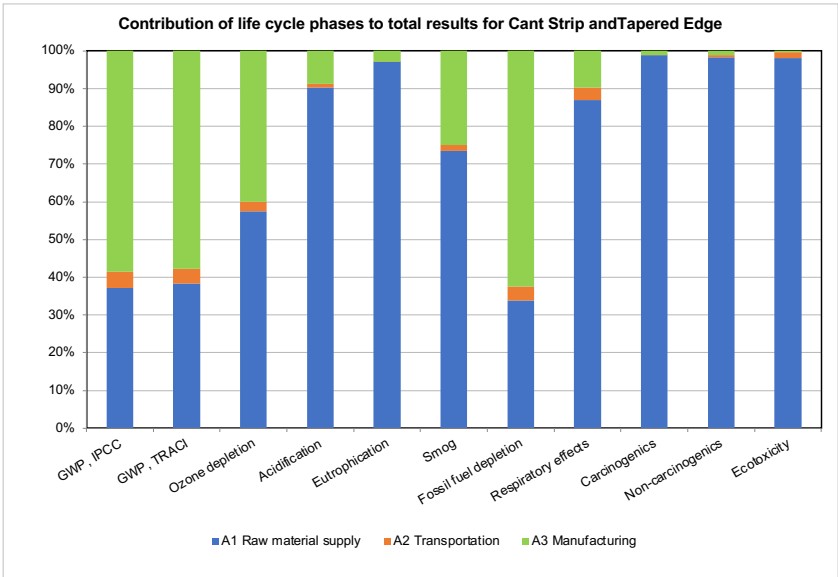


Figure 8 show the percent contribution of each stage of the production of Cant Strip and Tapered Edge. The raw material acquisition stage dominates the results for most impact categories (9 out of 11), followed by the manufacturing stage.

The total potential CO_2-equivalent emissions generated during the cradle-to-gate stage of Cant Strip and Tapered Edge production is 3.08E-01 kg CO_2-eq. The raw material acquisition stage contributed 1.18E-01 kg CO_2-eq, accounting for 38.29% of the total results, with a biogenic carbon uptake of 1.13E-01 CO_2-eq. The manufacturing stage generated 1.77E-01 CO_2-eq, accounting for 57.67%. The manufacturing stage was only dominant for fossil fuel depletion. The raw material acquisition stage has a larger contribution than the manufacturing stage for most impact categories including notably ecotoxicity (99%), eutrophication (97%), and carcinogenics and non-carcinogenics (98%).

The SM2013 Methodology single-figure millipoint (mPts) score by life cycle phase for this product is presented below (Table 35). Across all 10 impact

categories, the SM single-figure score indicates that raw materials acquisition accounts for around 86.9% of the total impacts, manufacturing for 11.6%, and transportation for 1.4%.

Table 33. Life cycle impact assessment results for BLUE RIDGE FIBERBOARD Cant Strip and Tapered Edge per declared unit (1 m)

Impact category	Unit	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{TOTAL}$	kg CO_2 eq	-5.86E-03	1.26E-02	2.83E-01	**2.90E-01**
GWP, $IPCC_{BIOGENIC}$	kg CO_2 eq	-1.13E-01	0	1.13E-01	**0**
GWP, $IPCC_{FOSSIL}$	kg CO_2 eq	1.07E-01	1.26E-02	1.70E-01	**2.90E-01**
GWP, TRACI 2.1_{TOTAL}	kg CO_2 eq	5.00E-03	1.24E-02	2.90E-01	**3.08E-01**
GWP, TRACI $2.1_{BIOGENIC}$	kg CO_2 eq	-1.13E-01	0	1.13E-01	**0**
GWP, TRACI 2.1_{FOSSIL}	kg CO_2 eq	1.18E-01	1.24E-02	1.77E-01	**3.08E-01**
Ozone depletion	kg CFC-11 eq	4.53E-09	1.93E-10	3.15E-09	**7.87E-09**
Acidification	kg SO_2 eq	1.35E-03	1.47E-05	1.31E-04	**1.50E-03**
Eutrophication	kg N eq	1.15E-03	1.08E-06	3.30E-05	**1.18E-03**
Smog	kg O_3 eq	1.05E-02	2.27E-04	3.57E-03	**1.43E-02**
Fossil fuel depletion	MJ surplus	2.19E-01	2.37E-02	4.03E-01	**6.46E-01**
Additional environmental information					
Respiratory effects	kg PM2.5 eq	1.00E-04	3.87E-06	1.12E-05	**1.15E-04**
Carcinogenics	CTUh	98.86%	0.15%	1.00%	**100%**
Non carcinogenics	CTUh	98.24%	0.76%	0.99%	**100%**
Ecotoxicity	CTUe	98.04%	1.62%	0.34%	**100%**

Table 34. Percent contributions of each stage to each impact category for BLUE RIDGE FIBERBOARD Cant Strip and Tapered Edge per declared unit (1 m)

Impact category	A1 Raw material supply	A2 Transportation	A3 Manufacturing	Total
GWP, $IPCC_{BIOGENIC}$	37.08%	4.34%	58.58%	**100%**
GWP, $TRACI_{2.1}$	38.29%	4.04%	57.67%	**100%**
Ozone depletion	57.56%	2.45%	40%	**100%**
Acidification	90.27%	0.98%	8.74%	**100%**
Eutrophication	97.12%	0.09%	2.79%	**100%**
Smog	73.42%	1.59%	24.99%	**100%**
Fossil fuel depletion	33.94%	3.67%	62.39%	**100%**
Additional environmental information				
Respiratory effects	86.98%	3.35%	9.67%	**100%**
Carcinogenics	98.86%	0.15%	1.00%	**100%**
Non-carcinogenics	98.24%	0.76%	0.99%	**100%**
Ecotoxicity	98.04%	1.62%	0.34%	**100%**

Table 35. SM millipoint scores for BLUE RIDGE FIBERBOARD Cant Strip and Tapered Edge per declared unit (1 m)

Impact category	Unit	A1	A2	A3	Total
SM single figure score	mPts	4.48E-02	7.29E-04	5.98E-03	**5.15E-02**

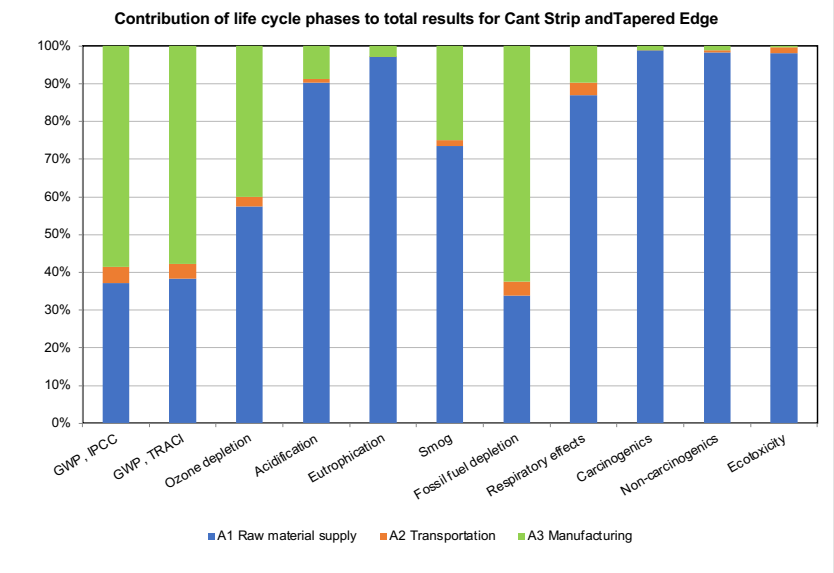


Figure 8. Contribution analysis of each impact category for Cant Strip and Tapered Edge

5.4 $GWP_{TRACI\ 2.1}$ Summary

Total Global Warming Potential (GWP) results (kg CO_2eq) using TRACI 2.1 methodology, per functional unit (kg/m3), for each product type (SOUNDSTOP, IBP, STRUCTODEK, INSULATING SHEATHING, and Cant Strip).

Table 36. Total Global Warming Potential (GWP) results (kg CO_2 eq) using TRACI 2.1 methodology, per functional unit (kg/m3) for BLUERIDGE SOUNDSTOP, IBP, STRUCTODEK, INSULATING SHEATHING products, and (kg/m) for BLUERIDGE Cant Strip and Tapered Edge

Product	$GWP_{TRACI\ 2.1}$ (kg CO_2 eq)
SoundStop & IBP	1.89E+02
Structodek HD	2.08E+02
Premium Insulating Sheathing	2.10E+02
Cant Strip & Tapered Edge	3.08E-01

5.5 Sensitivity analysis

Since W. R. MEADOWS is interested in global warming potential impacts, and a bulk of the GWP impacts stems from manufacturing activities, a sensitivity analysis was conducted on electricity usage to assess the impact of increasing the renewable energy percentage from the current 7%, which reflects the residual mix for the subregion, to approximately 50%. Global warming, eutrophication, and fossil fuel depletion were chosen to be evaluated since different life cycle stages contributed differently to the total results for those categories. The results are presented in Table 37.

Table 37. Sensitivity analysis of increased energy from renewable sources

	Global warming		Eutrophication		Fossil fuel depletion	
	kg CO_2 eq emissions	% change	kg N eq emissions	% change	MJ surplus	% change
SoundStop & IBP						
Baseline	1.98E+02	-	3.85E-01	-	3.66E+02	-
After increasing to 50% from renewable energy sources	1.58E+02	-20.0%	3.74E-01	-2.71%	3.07E+02	-16.1%

The results indicate that the increase in renewable energy could reduce potential CO_2-equivalent emissions by approximately 20.0%, which shows that global warming potential is sensitive to increases in electricity from renewable energy sources. Fossil fuel depletion showed a decrease of approximately 16.1%, similarly reflecting its sensitivity to the same change. Eutrophication, however, was shown not to be as sensitive to this change, showing only an approximately 2.71% reduction in total impacts.

5.6 Overview of relevant findings

This study evaluated a range of inventory and environmental indicators for BLUE RIDGE FIBERBOARD products. Across all environmental indicators and product configurations, the primary finding was that the raw material acquisition stage and manufacturing stage are responsible for much of the impacts within each impact category.

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 3.2% of the total impacts, depending on the specific impact category.

The manufacturing stage is the primary contributor to global warming potential across most product types. The findings are consistent with the amount of energy required to process wood chips and other raw materials into fiberboard products.

5.7 Conclusions and recommendations

The goal of this study was to conduct a cradle-to-gate LCA on the BLUE RIDGE FIBERBOARD products so as 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 seven out of ten TRACI 2.1 categories, with the exception of global warming potential, ozone depletion, and fossil fuel depletion. The manufacturing stage dominates the results in those impact categories for most products.

As the impacts from raw material acquisition are highest for most impact categories, W. R. MEADOWS can focus its efforts on its supply chain. Among the raw materials used, the virgin wood chips and starch together contribute to over 80% of the total GWP results in the raw material acquisition phase. It is recommended that W. R. MEADOWS considers designs for its fiberboard products that use an increased amount of post-industrial wood chips, and into designs which use less material overall to fulfill the same functions. Partnering with suppliers who use sustainable materials, renewable energy, or energy-efficient manufacturing methods may also help further reduce impacts.

Since impacts from manufacturing are highest for global warming potential, it is recommended that W. R. MEADOWS adopts less energy-intensive methods for processing wood chips and increases the use of renewable energy in the grid. A sensitivity analysis revealed that switching to an electricity mix that uses 50% from renewable energy sources could reduce potential CO_2-equivalent emissions

by approximately 20%. Reducing the amount of natural gas used is also expected to reduce total impacts in this phase.

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

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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]