LIFE CYCLE ASSESSMENT (LCA) OF BAMCORE PRIME WALL™ PANEL

Status Public

Client BamCore

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1 INTRODUCTION

1.1 Opportunity

BamCore's mission is to decarbonize the built environment by harnessing the best of nature and technology [1]. As part of this goal to turn buildings into climate solutions, BamCore has conducted a company-specific Life Cycle Assessment (LCA) to evaluate the environmental impacts of a selected product throughout the production stage, from raw material supply through manufacturing. To achieve a comprehensive understanding of the product's impact, BamCore has adopted a cradle-to-gate approach in conducting the LCA.

BamCore has engaged Sustainable Minds, an external practitioner, to develop an LCA for their Prime Wall™ framing system. The objective of the LCA is to identify the full range of environmental impacts of the panels, create an environmental product declaration (EPD) for use in business-to-business communications and communicating information to the market, identify areas where impacts can be reduced, acquire data for future product improvements, and contribute towards satisfying credits required in green building certifications such as the Leadership in Energy and Environmental Design (LEED®) building rating system or the Living Building Challenge. This project is critical to BamCore's commitment to providing the market with the necessary information to evaluate the environmental impacts of their products.

BamCore intends to use the LCA results to develop Sustainable Minds Transparency Reports™ (TRs), which are ISO 14025 Type III Environmental Declarations (EPDs) that can be used for communication with other companies, architects, and BamCore customers. Additionally, the TRs can be utilized in whole building LCA tools, in conjunction with the LCA background report and Life Cycle Inventory (LCI). The study aims to comply with the requirements of ISO 14040/14044, ISO 21930 standards, and UL's product category rules (PCRs) for Building Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements, version 4.0, and Part B: Structural and Architectural Wood Products EPD Requirements, version 1.1 [2] [3].

1.2 Life cycle assessment

This LCA report follows an attributional approach and comprises four key phases:

- Goal and scope definition
- Life cycle inventory analysis
- Life cycle impact assessment
- Interpretation of results

For Type III Environmental Declarations, a critical review of the LCA and an independent verification of the Transparency Reports (TRs) are mandatory. This project includes both.

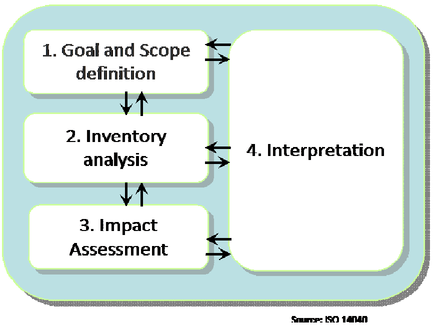


Figure 1. Phases in an LCA

1.3 Status

The information presented in this LCA report is based on the inputs and outputs provided by BamCore at the time of data collection, and Sustainable Minds and BamCore adhered to best practices in transforming the Life Cycle Inventory into this report.

The data used in this report covers the annual manufacturing data for the 12-month period of September 2021 through August 2022 from BamCore's plant located in Ocala, FL. Also included in this report is secondary data from select raw material suppliers and literature data to complete the inventory and fill gaps as necessary. Primary supplier data was provided for the bamboo plantation management and bamboo slat raw material production.

In instances where data was not available, assumptions were made based on similar supplier data or manufacturing data from BamCore's resources and other literature data. Expertise from BamCore employees was utilized to develop estimates or assumptions for upstream activities as needed.

The LCA critical review and verification of the Sustainable Minds Transparency Report / EPD was carried out by Tom Gloria, Industrial Ecology Consultants, LLC, and found to be compliant with ISO 14040/14044 and the relevant PCRs.

1.4 Team

This LCA report is the outcome of the efforts of the project team, led by Kate Chilton and Nicholas Allan on behalf of BamCore, with support from BamCore personnel during the data collection, reporting, and interpretation phases.

1.5 Structure

The subsequent sections of this LCA report are structured as follows:

Section 2: Goal and scope definition
Section 3: Life cycle inventory analysis
Section 4: Life cycle impact assessment methods
Section 5: Results and interpretation

This report incorporates LCA terminology. To facilitate comprehension, special consideration has been given to list definitions of significant terms used at the end of this report.

2 GOAL AND SCOPE

This section outlines the objective and scope of the LCA study. The goal and scope establish the boundaries of the analysis and define the level of detail and comprehensiveness of the assessment for the product in question.

2.1 Intended application and audience

This LCA report aims to illustrate the application of the LCA methodology to the Prime Wall™ cradle-to-gate life cycle. The report serves both internal and external purposes and is intended for a diverse audience. This audience includes the program operator (Sustainable Minds) and reviewer responsible for assessing the LCA for conformance to the PCR, as well as BamCore's internal stakeholders in marketing and communications, operations, and design.

The results will be made available to the public in a Sustainable Minds Transparency Report / EPD (Type III environmental declaration per ISO 14025), which is intended for communication between businesses and consumers.

2.2 Product description

The BamCore Prime Wall™ system (Figure 2) is currently comprised of Generation 3 panels which are a hybrid of bamboo and wood. Two structural panels form the interior and exterior faces of the wall assembly. The panels are fastened to wood plates at the top and bottom of the wall assembly and from one panel to the next contiguous panel, as specified by approved construction documents. Contiguous panels are fastened to each other using lap joints. Blocking between panels is added per specific job requirements. The result is a dual panel studless wall system. Prime Wall™ panels are fabricated to a job-specific engineered plan and delivered to the jobsite with materials as specified in BamCore-to-client contracts. The most applicable CSI classification for this product is 06 17 19.

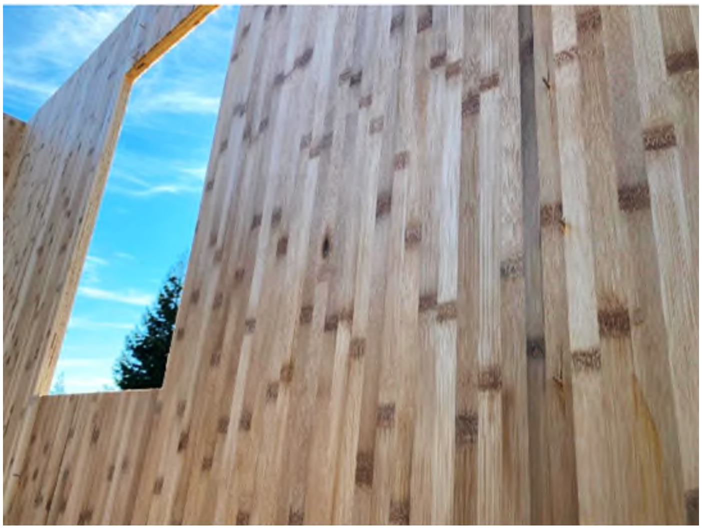


Figure 2. BamCore panelized Prime Wall™ system

The panels consist of multiple veneer layers covered with nominal 4.8 mm to 6.4 mm bamboo pieces on both faces and have a nominal thickness of 32 mm (Figure 3). The Prime Wall™ system may be designed with plate widths that allow outer wall dimensions from 203 mm to 349 mm. The finished wall assembly has a cavity that is slightly smaller than the width of the plate, and individual panels are manufactured with routed edges to form half lap joints at adjoining panel edges. The half lap joint is 25 mm wide; each panel has half their depth in the connection.

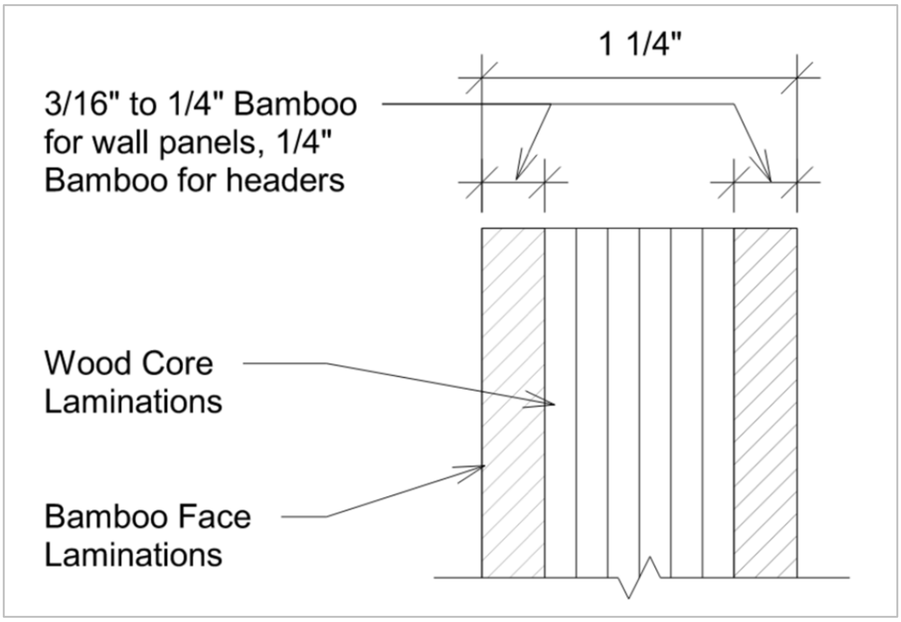


Figure 3. BamCore Prime Wall^{TM} panel composition

The BamCore Prime Wall^{TM} system is code-compliant up to 5 stories high and can be used in residential and commercial low-rise buildings. During the period selected for the LCA, panels were manufactured in BamCore's plant in Ocala, FL.

The patented engineering and design of the Prime Wall^{TM} system results in several functional performance attributes that are superior to traditional stud-based framing. These include increased strength and load-bearing capacity, better thermal performance and thus energy efficiency, and acoustic opacity as well as faster assembly and reduced waste.

2.3 Declared unit

In accordance with the PCR, a declared unit must be used when assessing the environmental impact of a building product, defined as an item used during the life cycle of a building or any other type of construction works. Per the PCR, the declared unit is taken as one cubic meter (m^3) of wall panel. For the purposes of reporting, LCA results were also calculated for one square foot (ft^2) of panel. Associated properties for a Prime Wall^{TM} panel are indicated in Table 3.

Table 3. Declared Unit Properties

Name	Value (m^3)	Value (ft^2)	Unit
Mass	584 (1287)	1.72 (3.80)	kg (lb)
Thickness	n/a	0.0318 (1.25)	m (in)
Density	584 (36.4)		kg/m3 (lb/ft^3)
Moisture Content	10		%

The declared unit of ft^2 was added for users of the LCA and EPD to apply values more easily to an area of wall face. The standard thickness of the Prime Wall^{TM} panel of 31.8mm (1.25 in) was used to convert ft^2 to m^3. The panel density has been 3rd party tested on specific plywood and bamboo thicknesses, which were within 1% of estimated panel density for that version of the product. During the LCA data collection period, 93% of panels produced had bamboo thickness of 4.8mm (3/16in) and 7% had bamboo thickness of 6.4mm (1/4in). The average bamboo and plywood thicknesses, their densities, and the added weights of adhesive solids were used to calculate the average product weights. Table 4 shows the various components that make up a Prime Wall™ production panel, per declared unit and as a percentage of the total mass, excluding packaging.

Table 4. Mass components per declared unit for a production panel

Flow	kg per ft^2	kg per m^3	% mass
Plywood	[redacted]	[redacted]	50-60%
Bamboo	[redacted]	[redacted]	40-50%
Adhesives	[redacted]	[redacted]	1-3%
Others	[redacted]	[redacted]	<1%

2.4 System Boundaries

This section describes the system boundaries for the modeled products. The system boundaries define which life cycle stages are included and which are excluded.

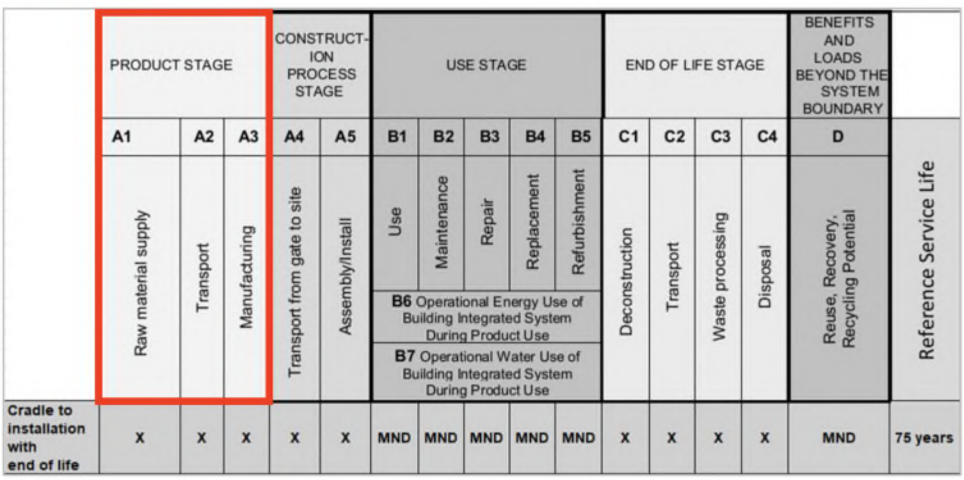
This LCA's system boundary includes the following life cycle stages:

I. A1-A3

- Raw materials acquisition, transportation to product manufacturing facility, processing of raw materials, and product manufacturing (production)

These boundaries apply to the modeled products and can be referred to as "cradle-to-gate" which means that it includes the life cycle stages and modules in the product stage as identified in the PCR. The life cycle includes all industrial processes from raw materials acquisition and pre-processing through panel production. Fabrication activities have been left out of this analysis as this step is to be interpreted as part of the installation phase (A5) due to the site/customer specific aspects of this step.

The system boundaries for the Prime Wall™ panel are detailed below. Figure 4 represents the life cycle stages included in this study (outlined in the red box). Table 6 lists specific inclusions and exclusions for the system boundaries.



	PRODUCT STAGE			CONSTRUCT-ION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY	
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	
	Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use of Building Integrated System During Product Use	Operational Water Use of Building Integrated System During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential	Reference Service Life
Cradle to installation with end of life	X	X	X	X	X	MND	MND	MND	MND	MND			X	X	X	X	MND	75 years

Figure 4. Applied system boundaries for the modeled product

Table 6. Applied system boundary

Included	Excluded
• Raw material extraction • Processing of raw materials • Energy production • Manufacture, transport, and disposal of packaging materials not associated with final product • Transport of raw materials and waste • Manufacturing activities • Packaging of final products	• Construction of capital equipment • Maintenance and operation of support equipment • Human labor and employee transport • Overhead energy not associated with manufacturing processes • Fabrication activities

2.4.1. A1-A3: Raw materials acquisition, transportation, and manufacturing

Raw materials acquisition and transportation (A1-A2) These product stages include, where relevant, the following processes:

- Extraction and processing of raw materials
- Average transport of raw materials from extraction/production to manufacturer
- Transport of materials between manufacturer sites

A description of the most important modeling parameters is included below.

Manufacturing (A3) The manufacturing stage includes the following:

- Production of panels
- Packaging
- Releases to environmental media (air, soil, ground, and surface water)
- Manufacturing waste

2.4.2. Other life cycle stages

This study does not account for distribution and installation, the use stage, end-of-life stage, or for benefits and loads beyond the system boundary.

3 INVENTORY ANALYSIS

This section includes an overview of the obtained data and data quality that has been used in this study. A complete 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

Data used for this project represents a mix of primary data collected from BamCore's bamboo suppliers, primary data on the manufacturing of Prime Wall^{TM} panels at BamCore facilities (gate-to-gate), and background data from databases available in SimaPro, primarily ecoinvent v3.8. Overall, the quality of the data used in this study is considered to be good and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness as described below.

- **Gate-to-gate:** Data on processing materials and manufacturing the panels was collected in a consistent manner and level of detail to ensure high quality data. All submitted data was checked for quality multiple times on the plausibility of inputs and outputs. All questions regarding data were resolved with BamCore. Data was collected at BamCore's Ocala, FL facility. The production of panels was 1,699 m^3 during this period. Inventory calculations were assisted by an analyst at Sustainable Minds and subsequently checked by a supporting consultant.
- **Background data:** The model was constructed in SimaPro with consistency in mind. Expert judgment and advice were used in selecting appropriate datasets to model the materials and energy for this study and has been noted in the preceding sections. Detailed database documentation for ecoinvent v3.8 can be accessed at: https://ecoinvent.org/the-ecoinvent-database/.

This LCA utilized primary data provided by BamCore from operations between September 2021 and August 2022. The data was thoroughly reviewed upon receipt to ensure completeness and plausibility through various methods, including mass balance and benchmarking. In the case of any gaps, outliers, or other inconsistencies, follow-up questions and conversations were used to clarify data and responses. Sustainable Minds engaged in productive discussions with BamCore to address and resolve any open issues in a timely and efficient manner.

3.2 Primary data

The panelized wall system represented in this study is produced in several stages that involve harvesting and pre-processing the bamboo, combining the bamboo with wood to form the engineered production panel, and then custom prefabricating the panels to millimeter accuracy. The finished panels are then palletized and prepared for distribution to construction sites where they are installed. [redacted].

[redacted]

Figure 5. Life cycle flow chart of production

Data used in this analysis represents the production of a Prime Wall^{TM} panel from BamCore. Results were then scaled to reflect the declared unit. This was done because BamCore produces varying sizes of panels, both 4'x8' and 4'x10'. To account for this, the data was normalized to amounts per square foot and then converted to amounts per cubic meter based on averages.

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

BamCore's Prime Wall™ panels consist of two major components: bamboo slats and a plywood core. Bamboo is harvested from plantations located in the tropics/subtropics, [redacted] and partially processed in the plantation by cutting to length, longitudinally ripping, and partially plaining using fuel powered tools to create rough slats. The bamboo is then transported to a nearby facility to be further pre-processed. In some instances, the harvested bamboo is packaged up [redacted] in order to transport it. Next, the slats are treated to remove pests [redacted] and are then dried. Waste generated from harvesting the bamboo is often used as biofuel in the drying processes. Finally, the slats are prepared for shipment overseas to Florida [redacted]. Plywood is harvested [redacted] and transported to BamCore's Florida facility via ocean freighter and trucks.

An [redacted] adhesive is used to bind individual bamboo slats into wider slat sheets. An [redacted] adhesive is used to bind the bamboo slat sheets and the plywood core together. A water-based sealer is applied to the edges of the panel to minimize moisture damage and reduce checking and splitting. In some instances, a medium density overlay (MDO) paper is added to the exterior face of the panel.

Packaging is used to bulk transport panels between BamCore facilities. Wood dunnage, in conjunction with covers made from leftover/unused plywood, is used to carry the panels. The stacks of panels produced in Ocala are secured with steel banding and covered with plastic sheets for temporary storage and transportation.

These additional raw material and packaging inputs are transported to BamCore's facilities via truck. Transport data for all inputs, including packaging, was collected for each flow and is shown in Table 8.

The product does not contain substances that are identified as hazardous according to standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C, nor does it (or its associated processes) release dangerous, regulated substances that affect health and environment, including indoor air emissions, gamma or ionizing radiation emissions, or chemicals released to the air or leached to water and soil.

Table 8. Raw material inputs per declared unit of Prime Wall™ panel produced in Ocala

Material Inputs	Transportation mode	Distance (km)
Raw Material		
Plywood	Sea freight + truck	[redacted]
Plywood packaging	Sea freight + truck	[redacted]
Bamboo slats	Sea freight + truck	[redacted]
Bamboo slats packaging	Sea freight + truck	[redacted]
Edge sealer	Truck	[redacted]
MDO paper	Truck	[redacted]
[redacted]	Truck	[redacted]
[redacted]	Truck	[redacted]
Packaging		
Steel banding	Truck	[redacted]
Wood dunnage	Truck	[redacted]
Plastic sheets	Truck	[redacted]
Plywood	Sea freight + truck	[redacted]

3.2.2. Manufacturing (A3)

After raw materials are transported to BamCore, we begin production of the Prime Wall™ panels. This starts by doing final four-sided planing of the rough slat feedstock and creating slat sheets by two directional pressing of the bamboo planed slats. Then two bamboo veneers are pressed onto both faces of the plywood core, sometimes with an added MDO skin on one side. Next, we square and lap cut the pressed panels. Finally, we calibrated sand the panels to their correct thickness.

The Ocala facility has a collection and recycling process in place for the sawdust generated during the cutting/trimming steps. In addition, the steel banding that is sent from Ocala as part of the transport packaging is recycled. The remaining waste generated is sent to landfill. Only waste sent to landfill is included in the analysis – impacts from recycling are not included in the model as the impacts from processing it into a secondary material are outside the scope.

Table 9 below lists the inputs and outputs for the manufacturing processes. Annual data was collected, which was later normalized to the declared unit using the annual production throughput. Electricity data was isolated to only include what was needed to run manufacturing machines (i.e., overhead data such as lighting for office spaces was excluded).

Table 9. Inputs and outputs for production of 1 ft^2 and 1 m^3 of Prime Wall™ panel

	Flow	Amount (ft^2)	Amount (m^3)	Unit
Inputs	Electricity	[redacted]	[redacted]	[redacted]
	Propane	[redacted]	[redacted]	[redacted]
Outputs	Production panel	[redacted]	[redacted]	[redacted]
	Landfill waste	[redacted]	[redacted]	[redacted]

3.3 Data selection and quality

Data requirements provide guidelines for data quality in the LCA and are important to ensure data quality is consistently tracked. Data quality considerations include precision, completeness, and representativeness. The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data is likely to be better (i.e., more precise) than calculated values or values from literature. A range of precision exists within the primary data. Verified data based on measurements is used whenever possible. In instances where this level of reliability is unavailable, verified/unverified data based partly on assumptions and/or measurements or qualified estimates are used.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. Wherever data was available on material and energy flows, these were included in the model. No known flows are deliberately excluded from this analysis other than those defined to be outside the defined system boundaries. Inquiries were made to the BamCore team and a review with key stakeholders leads to the conclusion that the dataset is complete.
- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between

product systems, and not due to inconsistencies in modeling choices, data sources, or emission factors.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

An evaluation of the data quality with regard to these requirements is provided in the interpretation section of this report.

Time coverage:
Primary data was collected for September 2021 through August 2022. To better reflect current and future operations, select supplier data from this time period was chosen to model proportions of inputs that did not occur during this timeframe but that are more representative of what actually happens today. Background data for upstream and downstream processes (i.e., raw materials, energy resources, transportation, and ancillary materials) was obtained from the ecoinvent database in SimaPro.

Technology coverage:
Data was collected for Prime Wall™ panel manufacturing at BamCore's facilities in the US.

Geographical coverage:
Primary data from bamboo suppliers located in [redacted] and [redacted] was collected in addition to primary data from BamCore's operations in the US. As such, the geographical coverage for this study is based on an upstream system boundary for bamboo outside of the US and a US-based system boundary for all other processes and products. Whenever US background data sets were not readily available, European or global data were used as proxies.

3.4 Background data

This section details background datasets used in modeling the environmental performance of Prime Wall™ panels. Each table lists dataset purpose, name, source, reference year, and location.

All data from the ecoinvent v3.8 database was created with consistent system boundaries and upstream data. Expert judgment and advice were used in selecting appropriate datasets to model the materials and energy for this study. Detailed database documentation for ecoinvent can be accessed at: https://ecoinvent.org/the-ecoinvent-database/.

3.4.1. Fuels and energy

National and regional averages for fuel inputs and electricity grid mixes were obtained from the ecoinvent v3.8 database within SimaPro. Table 10 shows the most relevant LCI datasets used in modeling the product systems.

Table 10. Key energy datasets used in inventory analysis

Energy	Dataset name	Primary source	Reference year	Geography
Electricity	[redacted]	Ecoinvent v3.8	2022	[redacted]
Electricity	Electricity, medium voltage {SERC}| market for electricity, medium voltage | Cut-off, U	Ecoinvent v3.8	2022	US – SERC
Propane	Propane, burned in building machine {GLO}| market for propane, burned in building machine | Cut-off, U	Ecoinvent v3.8	2014	Global
Gasoline	Manual process dataset based on: Petrol, unleaded {RoW}| market for petrol, unleaded | Cut-off, U	Ecoinvent v3.8	2011	Global
Diesel	Manual process dataset based on: Diesel {RoW}| market for diesel | Cut-off, U	Ecoinvent v3.8	2011	Global
Motor oil	Manual process dataset based on: Petrol, two-stroke blend {GLO}| market for petrol, two-stroke blend | Cut-off, U	Ecoinvent v3.8	2011	Global

3.4.2. Raw materials extraction and transport

Data for upstream raw materials was obtained from BamCore suppliers and the ecoinvent v3.8 database. Table 11 shows the most relevant LCI datasets used in modeling the product systems. Data sets older than 10 years old were chosen because they closest represent the technology used to manufacture the material and are assumed to be more accurate than other proxies with more precise geography and temporal representativeness.

Table 11. Key material datasets used in inventory analysis

Raw material	Dataset name	Primary source	Reference year	Geography
Plywood	• Plywood {CA-QC}| plywood production | Cut-off, U • Plywood {RoW}| plywood production | Cut-off, U*	Ecoinvent v3.8	2020	[redacted]
Bamboo	Bamboo culm {RoW}| market for bamboo culm | Cut-off, U*	Ecoinvent v3.8	2020	Global
Water	Water, decarbonised {RoW}| market for water, decarbonised | Cut-off, U	Ecoinvent v3.8	2022	Global
[redacted]	[redacted]	Ecoinvent v3.8	2011	Global
[redacted]	[redacted]	Ecoinvent v3.8	2011	Global
[redacted]	[redacted]	Ecoinvent v3.8	2020	Global
MDO paper	Phenolic resin {RoW}| phenolic resin production | Cut-off, U*	Ecoinvent v3.8	2022	Global
[redacted]	[redacted]	Ecoinvent v3.8	2022	Europe
[redacted]	[redacted]	Ecoinvent v3.8	2022	Global
Steel banding	Steel, unalloyed {RoW}| steel production, converter, unalloyed | Cut-off, U*	Ecoinvent v3.8	2022	Global
Wood dunnage	Sawnwood, board, softwood, raw, dried (u=20%) {RoW}| board, softwood, raw, air drying to u=20% | Cut-off, U	Ecoinvent v3.8	2014	Global
Plastic sheets & twine	Polypropylene, granulate {RoW}| polypropylene production, granulate | Cut-off, U	Ecoinvent v3.8	2018	Global

*Represent proxy or modified datasets used

3.4.3. Transportation

Average transportation distances and modes of transport are included for the transport of the raw materials to production facilities. The transport of the finished product to the construction site is not accounted for. Table 12 lists relevant transport datasets used in the model.

Table 12. Key transportation datasets used in inventory analysis

Transportation	Dataset name	Primary source	Year	Geography
Truck	[redacted]	Ecoinvent v3.8	2021	[redacted]
Truck	Transport, freight, lorry 16-32 metric ton, EURO5 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO5 | Cut-off, U	Ecoinvent v3.8	2011	Global
Sea freight	Transport, freight, sea, bulk carrier for dry goods {GLO}| market for transport, freight, sea, bulk carrier for dry goods | Cut-off, U	Ecoinvent v3.8	2018	Global

3.4.4. Disposal

Disposal processes were also obtained from the Ecoinvent database. Table 13 presents the relevant disposal datasets used in the model.

Table 13. Key disposal datasets used in inventory analysis

Material disposed	Dataset name	Primary source	Year	Geography
Waste going to landfill	Municipal solid waste {RoW}| treatment of municipal solid waste, sanitary landfill | Cut-off, U	Ecoinvent v3.8	2010	Global
Wastewater	Wastewater, average {RoW}| treatment of wastewater, average, wastewater treatment | Cut-off, U	Ecoinvent v3.8	2022	Global
Waste plastic	Waste polypropylene {RoW}| treatment of waste polypropylene, sanitary landfill | Cut-off, U	Ecoinvent v3.8	2010	Global

3.4.5. Emissions to air, water, and soil

Data for all upstream materials, electricity, and energy carriers was obtained from the Ecoinvent v3.8 database. The emissions due to the use of electricity and fuels are accounted for within the database processes.

3.5 Limitations

Conducting a life cycle assessment (LCA) of a product system is an extensive and intricate process that inherently necessitates certain assumptions and simplifications. The study's limitations should be acknowledged as follows:

- This study is based on the aggregated primary data of country-specific bamboo suppliers, but actual operations at each of their plantations and pre-processing facilities vary. In addition, some of the bamboo suppliers provided partial primary data for their

operations. For gaps in data, an average from other suppliers was assumed.
- 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.

3.6 Criteria for the exclusion of inputs and outputs

Primary data for bamboo slat packaging was provided by our suppliers and included in the model. Packaging for all other inbound raw materials to BamCore was excluded as primary data for this was not provided, nor was it required under the scope of the PCR. Otherwise, all energy and material flow data available was included in the model and complied with the 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 is available. Data gaps shall be filled by conservative assumptions with average, generic or proxy data. Any assumptions for such choices shall be documented.
- Particular care should be taken to include material and energy flows that are known or suspected to release substances into the air, water, or soil in quantities that contribute significantly to any of the pre-set indicators of this document. In cases of insufficient input data or data gaps for a unit process, the cut-off criteria shall be 1% of renewable primary resource (energy), 1% of non-renewable primary resource (energy) usage, 1% of the total mass input of that unit process, and 1% of environmental impacts. The total of neglected input flows per module shall be a maximum of 5% of energy usage, mass, and environmental impacts. When assumptions are used in combination with plausibility considerations and expert judgement to demonstrate compliance with these criteria, the assumptions shall be conservative.
- All substances with hazardous and toxic properties that can be of concern for human health and/or the environment shall be identified and declared according to normative requirements in standards or regulation applicable in the market for which the EPD is valid, even though the given process unit is under the cut-off criterion of 1% of the total mass.

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.

Capital goods such as saw lines, [redacted] presses, and CNC machines are expected to last for the life of the plant, and the plant is expected to last at least 30 years. Therefore, they are assumed not to significantly affect the conclusions of the LCA nor additional environmental information.

3.7 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 where and how allocation occurs in the modeling of the LCA. In this LCA, the following rules have been applied.

The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring.

No co-product allocation was necessary since each facility produced a single panel type. The manufacturing inputs and outputs were divided evenly among the panels produced by area.

3.8 Software and database

The LCA model was created using SimaPro Developer 9.5. Ecoinvent and other databases listed in section 3.4 provide the life cycle inventory data for the raw materials and processes for modeling the products.

3.9 Critical review

This is a supporting LCA report for the Prime Wall™ panel Transparency Report. Both this background report and the Transparency Report were evaluated for conformance to the PCR according to ISO 14025 [4] and the ISO 14040/14044 standards [5]. Critical review was performed by Tom Gloria, and access to a public version of this critically reviewed report can be found linked in the references section of the Transparency Report.

4 IMPACT ASSESSMENT METHODS

4.1 Impact assessment

The environmental indicators as required by the PCR are included as well as other indicators required to derive the SM2013 single score [6] (see Table 14). 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 14. 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, LHV	Fossil fuel depletion is the surplus energy to extract minerals and fossil fuels.

[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 functional unit. The two periods are related as follows: all environmental impacts that are created in the period of the functional 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/

With respect to global warming potential, biogenic carbon is included in impact category calculations. Greenhouse gas emissions from land-use change are expected to be insignificant and were not reported.

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 would 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 15 conforming to the SM 2013 Methodology were applied.

Table 15. 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 section includes the results from the LCA for the product studied. It details the results per product per declared unit, provides scaling factors, outlines the sensitivity analysis, and concludes with recommendations.

5.1 Life cycle inventory results

Resource use indicators, output flows and waste category indicators, and carbon emissions and removals are presented in this section. LCI flows were calculated with the help of the American Center for Life Cycle Assessment guidance to the ISO 21930:2017 metrics [10].

Resource use indicators represent the amount of materials consumed to produce not only the product itself, but the raw materials, electricity, 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 total water used over the entire life cycle. No renewable energy was used in production beyond that accounted for in the electricity grid mixes used, and no energy was recovered. The biogenic carbon content of bio-based materials is reported per module.

Tables 16 and 17 show resource use, output and waste flows, and carbon emissions and removals for each declared unit of Prime Wall™ panel.

Table 16. Resource use, output and waste flows, and carbon emissions and removals per ft^2 of production panel

		Production Panel					
Metric	**Unit**	**A1**	**A2**	**A3**	**A5**	**CE/C4**	**TOTAL**
Resource use indicators							
RPRe	MJ, LHV	5.57E+01	7.52E-03	1.03E+00	MND	MND	5.67E+01
RPRm	MJ, LHV	3.44E+01	0.00E+00	0.00E+00	MND	MND	3.44E+01
NRPRe	MJ, LHV	1.23E+01	4.87E+00	1.92E+01	MND	MND	3.64E+01
NRPRm	MJ, LHV	2.36E+00	0.00E+00	0.00E+00	MND	MND	2.36E+00
SM	kg	0.00E+00	0.00E+00	4.88E-02	MND	MND	4.88E-02
RSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
NRSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
RE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
FW	m3	1.01E+01	3.50E-02	3.24E+00	MND	MND	1.34E+01
Output flows and waste category indicators							
HWD	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	4.32E-02	MND	MND	4.32E-02
HLRW	kg	8.61E-11	2.77E-13	7.37E-11	MND	MND	1.60E-10
ILLRW	kg	6.33E-10	9.56E-13	5.87E-10	MND	MND	1.22E-09
CRU	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
MR	kg	0.00E+00	0.00E+00	9.05E-02	MND	MND	9.05E-02
MER	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
EE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
Carbon emissions and removals							
BCRP	kg CO2	3.08E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E+00
BCEP	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E+00	3.08E+00
BCRK	kg CO2	4.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.33E-01
BCEK	kg CO2	0.00E+00	0.00E+00	0.00E+00	4.33E-01	0.00E+00	4.33E-01
BCEW	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- [RPRE - Renewable primary energy used as energy carrier (fuel)];
- [RPRM - Renewable primary resources with energy content used as material];
- [NRPRE - Non-renewable primary resources used as an energy carrier (fuel)];
- [NRPRM - Non-renewable primary resources with energy content used as material];
- [SM - Secondary materials];
- [RSF - Renewable secondary fuels];
- [NRSF - Non-renewable secondary fuels];
- [RE - Recovered energy];
- [FW - Use of net fresh water resources]
- [HWD - Hazardous waste disposed];
- [NHWD - Non-hazardous waste disposed];
- [HLRW - High-level radioactive waste, conditioned, to final repository];
- [ILLRW - Intermediate- and low-level radioactive waste, conditioned, to final repository];
- [CRU - Components for re-use];
- [MR - Materials for recycling];
- [MER - Materials for energy recovery];
- [EE - Exported energy];
- [BCRP - Biogenic Carbon Removal from Product];
- [BCEP - Biogenic Carbon Emission from Product];
- [BCRK - Biogenic Carbon Removal from Packaging];
- [BCEK - Biogenic Carbon Emission from Packaging];
- [BCEW - Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes];
- [CCE - Calcination Carbon Emissions];
- [CCR - Carbonation Carbon Removals];
- [CWNR - Carbon Emissions from Combustion of Waste from Non- Renewable Sources used in Production Processes]

Table 17. Resource use, output and waste flows, and carbon emissions and removals per m^3 of production panel

		Production Panel					
Metric	**Unit**	**A1**	**A2**	**A3**	**A5**	**CE/C4**	**TOTAL**
Resource use indicators							
RPRe	MJ, LHV	1.89E+04	2.55E+00	3.50E+02	MND	MND	1.93E+04
RPRm	MJ, LHV	1.17E+04	0.00E+00	0.00E+00	MND	MND	1.17E+04
NRPRe	MJ, LHV	4.17E+03	1.65E+03	6.52E+03	MND	MND	1.23E+04
NRPRm	MJ, LHV	7.99E+02	0.00E+00	0.00E+00	MND	MND	7.99E+02
SM	kg	0.00E+00	0.00E+00	1.66E+01	MND	MND	1.66E+01
RSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
NRSF	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
RE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
FW	m3	3.43E+03	1.19E+01	1.10E+03	MND	MND	4.54E+03
Output flows and waste category indicators							
HWD	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
NHWD	kg	0.00E+00	0.00E+00	1.46E+01	MND	MND	1.46E+01
HLRW	kg	2.92E-09	9.40E-11	2.50E-08	MND	MND	2.80E-08
ILLRW	kg	2.14E-07	3.24E-10	1.99E-07	MND	MND	4.13E-07
CRU	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
MR	kg	0.00E+00	0.00E+00	3.07E+01	MND	MND	3.07E+01
MER	kg	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
EE	MJ, LHV	0.00E+00	0.00E+00	0.00E+00	MND	MND	0.00E+00
Carbon emissions and removals							
BCRP	kg CO2	1.04E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E+03
BCEP	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E+03	1.04E+03
BCRK	kg CO2	1.47E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.47E+02
BCEK	kg CO2	0.00E+00	0.00E+00	0.00E+00	1.47E+02	0.00E+00	1.47E+02
BCEW	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR	kg CO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- [RPRE - Renewable primary energy used as energy carrier (fuel)];
- [RPRM - Renewable primary resources with energy content used as material];
- [NRPRE - Non-renewable primary resources used as an energy carrier (fuel)];
- [NRPRM - Non-renewable primary resources with energy content used as material];
- [SM - Secondary materials];
- [RSF - Renewable secondary fuels];
- [NRSF - Non-renewable secondary fuels];
- [RE - Recovered energy];
- [FW - Use of net fresh water resources]
- [HWD - Hazardous waste disposed];
- [NHWD - Non-hazardous waste disposed];
- [HLRW - High-level radioactive waste, conditioned, to final repository];
- [ILLRW - Intermediate- and low-level radioactive waste, conditioned, to final repository];
- [CRU - Components for re-use];
- [MR - Materials for recycling];
- [MER - Materials for energy recovery];
- [EE - Exported energy];
- [BCRP - Biogenic Carbon Removal from Product];
- [BCEP - Biogenic Carbon Emission from Product];
- [BCRK - Biogenic Carbon Removal from Packaging];
- [BCEK - Biogenic Carbon Emission from Packaging];
- [BCEW - Biogenic Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes];
- [CCE - Calcination Carbon Emissions];
- [CCR - Carbonation Carbon Removals];
- [CWNR - Carbon Emissions from Combustion of Waste from Non- Renewable Sources used in Production Processes]

5.2 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 substances would 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 on category endpoints, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are shown for the Prime Wall^{TM} manufactured by BamCore. 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 [11]. USEtox indicators are used to evaluate human toxicity and ecotoxicity, results will be reported only as a contribution analysis. The SM 2013 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 [7].

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.

5.2.1. Impact assessment results

The impact results have been calculated per declared unit of Prime Wall^{TM} panel for each life cycle stage in Table 18 with percent contributions displayed in Table 19.

The results indicate that for production of a Prime Wall^{TM} panel, the raw material acquisition stage is the highest contributor for all impact categories. The raw materials acquisition stage impact is predominately due to the plywood and bamboo slat inputs. The manufacturing stage has the second highest contribution to most impact categories, primarily due to the electricity required to operate the production machinery.

Table 18. LCIA results per ft² and m³ of production panel

Impact category	Unit	Production Panel							
		A1		A2		A3		Total	
		ft²	m³	ft²	m³	ft²	m³	ft²	m³
Ozone depletion (ODP)	kg CFC-11 eq	2.17E-8	7.35E-6	5.66E-9	1.92E-6	1.00E-8	3.39E-6	3.74E-8	1.27E-5
Global warming	kg CO_2 eq	1.01E+0	3.44E+2	3.73E-1	1.26E+2	9.96E-1	3.38E+2	2.38E+0	8.08E+2
Smog (SFP)	kg O_3 eq	2.87E-1	9.72E+1	7.88E-2	2.67E+1	2.33E-2	7.90E+0	3.89E-1	1.32E+2
Acidification (AP)	kg SO_2 eq	9.49E-3	3.22E+0	4.30E-3	1.46E+0	1.84E-3	6.24E-1	1.56E-2	5.30E+0
Eutrophication (EP)	kg N eq	1.15E-2	3.91E+0	1.87E-4	6.34E-2	4.40E-4	1.49E-1	1.22E-2	4.13E+0
Respiratory effects	kg $PM_{2.5}$ eq	1.49E-8	5.04E-6	2.92E-1	9.90E-8	2.30E-9	7.80E-7	1.75E-8	5.92E-6
Carcinogenics	CTUh	1.33E-6	4.51E-4	3.20E-8	1.08E-5	4.08E-8	1.38E-5	1.40E-6	4.76E-4
Non-carcinogenics	CTUh	1.57E-3	5.32E-1	2.99E-4	1.01E-1	7.82E-4	2.65E-1	2.65E-3	8.99E-1
Ecotoxicity	CTUe	3.82E+0	1.30E+3	6.07E-1	2.06E+2	8.95E-2	3.03E+1	4.52E+0	1.53E+3
Fossil fuel depletion (ADP_{fossil})	MJ, LHV	1.99E+0	6.76E+2	7.34E-1	2.49E+2	1.43E+0	4.85E+2	4.16E+0	1.41E+3

Table 19. Percent contributions of each life cycle stage

Impact category	Unit	Production Panel		
		A1	A2	A3
Ozone depletion (ODP)	kg CFC-11 eq	58%	15%	27%
Global warming	kg CO_2 eq	43%	16%	42%
Smog (SFP)	kg O_3 eq	74%	20%	6%
Acidification (AP)	kg SO_2 eq	61%	28%	12%
Eutrophication (EP)	kg N eq	95%	2%	4%
Respiratory effects	kg $PM_{2.5}$ eq	85%	2%	13%
Carcinogenics	CTUh	95%	2%	3%
Non-carcinogenics	CTUh	59%	11%	30%
Ecotoxicity	CTUe	85%	13%	2%
Fossil fuel depletion (ADP_{fossil})	MJ, LHV	48%	18%	34%

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 20). They confirm the trends in the results using the impact assessment results before normalization and weighting.

Table 20. SM millipoint scores

Impact category	Unit	Production Panel							
		A1		A2		A3		Total	
		ft²	m³	ft²	m³	ft²	m³	ft²	m³
SM single figure score	mPt	2.21E-1	7.49E+1	2.13E-2	8.11E+0	3.74E-2	1.30E+1	2.83E-1	9.60E+1

5.3 Sensitivity analysis

The electricity consumed at the manufacturing facility is a key driver for the overall impacts in each impact category. Therefore, a sensitivity analysis was conducted by changing the amount of electricity consumed at each site by ± 20%. As tabulated in Table 21, increasing the electricity consumption by 20% will increase potential CO2-equivalent emissions in the A3 stage by 18% for Ocala, increasing the overall emissions by 7%. On decreasing the electricity consumption by 20%, potential CO2-equivalent emissions in the A3 stage decrease by 18% for Ocala, decreasing the overall emissions by 7%.

Table 21. Sensitivity analysis of LCIA results for A3 electricity

	A3 CO_2 eq Emissions										Total CO_2 eq Emissions									
	Base Electricity		20% more electricity		% with base	20% less electricity		% with base	Base Electricity		20% more electricity		% with base	20% less electricity		% with base
Facility	ft^2	m^3	ft^2	m^3		ft^2	m^3		ft^2	m^3	ft^2	m^3		ft^2	m^3	
Ocala, FL (production)	9.96E-1	3.38E+2	1.18E+0	4.00E+2	118%	8.12E-1	2.75E+2	82%	2.71E+0	9.19E+2	2.89E+0	9.81E+2	107%	2.53E+0	8.56E+2	93%

5.4 Overview of relevant findings

This Life Cycle Assessment (LCA) report evaluates a wide range of inventory and environmental indicators. The primary finding across all the environmental indicators considered was that within A1-A3, raw material acquisition (A1) contributes the most to the total impacts, with the exception of global warming for which manufacturing operations (A3) contribute the most. As is expected for highly engineered products, the primary driver of environmental impacts within the manufacturing stage is the energy required to run the machinery that assembles the panels.

Raw material sourcing and production constitutes a significant contribution to the impacts across all inventory and impact indicators. Unsurprisingly, plywood and bamboo emerge as the main contributors across all environmental indicators.

Another key finding is that cradle-to-gate global warming impact to produce a Prime Wall™ panel (A1-A3) are less than the associated biogenic carbon storage.

5.5 Discussion on 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). Primary data has been used, when available, for all unit processes.

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 is from ecoinvent databases with documented precision to the extent available.
- Completeness: All relevant process steps for the product system were considered and modeled. Each unit process was checked for mass balance and completeness of the emission inventory. Capital equipment was excluded as required by the PCR. Otherwise, no data were knowingly omitted.

Consistency and reproducibility

- Consistency: Assumptions, methods, and data were found to be consistent with the study's goal and scope. Primary data were collected with a similar level of detail, while background data were sourced primarily from the ecoinvent database, while 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. System boundaries, allocation rules, and impact assessment methods have also been applied uniformly.
- Reproducibility: Reproducibility is warranted as much as possible through the disclosure of input-output data, dataset 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: Primary data was determined to be representative of typical operations. Secondary data was obtained from the Ecoinvent databases and is typically representative of recent years. Temporal representativeness is considered to be good.
- Geographical: Primary data are representative of BamCore's facilities in the US. Global datasets have been used for most of the materials. Specific eGRID datasets have been used for each facility to represent electricity consumption. Geographical representativeness is considered to be good.
- Technological: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be good.

5.7 Conclusions and recommendations

The goal of this study was to conduct a cradle-to-gate LCA on a Prime Wall™ panel so as to develop an SM Transparency Report. The creation of this Transparency Report 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 driven primarily by raw material acquisition and manufacturing operations.

Since upstream raw material production and transportation both have a major impact on the results, this is an important area for BamCore to focus its efforts. Although they are not directly in control of these activities, opportunities exist to work with suppliers to improve the efficiency and sustainability of their harvesting and processing operations and/or work and shipping partners who use electric or hybrid fleets, for example.

The results show that a significant area for reduction of the product's environmental impact is in the manufacturing phase, particularly as it relates to energy usage. This is an important area for BamCore to focus its efforts on and one for which it can influence. In addition to working to reduce the use of electricity, BamCore can work with energy providers using greener energy mixes or consider installing solar panels to reduce the potential impacts to the environment. Furthermore, BamCore has the opportunity to reduce waste associated with production by exploring alternatives used for the bio-based material, such as cogeneration with biofuel or biochar production.

This study did not consider the energy savings associated with the use of a Prime Wall™ framing system in a building, nor does it include the carbon sequestration associated with the regrowth of the biobased materials used. It is expected that these savings, in conjunction with the carbon storage that is considered as part of this analysis, would far outweigh the impacts attributed to the raw material sourcing, manufacturing, transportation, and installation of the product.

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ACRONYMS

ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
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

- BamCore_LCA_Prime Wall Panel_LCI and LCIA indicators_fabrication panel_09012023
- BamCore_LCA_Prime Wall Panel_LCI and LCIA indicators_production panel_09012023
- BamCore_LCA_Prime Wall Panel_primary data_09012023