LIFE CYCLE ASSESSMENT (LCA)
OF DIGITAL BUILDING COMPONENTS
X-SERIES: PANELIZED EXTERIOR WALL SYSTEMS

Public version

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EXECUTIVE SUMMARY

Digital Building Components (DBC) is redefining the panelized wall systems industry through advanced digital modeling and off-site fabrication. Their high-performance, fully coordinated wall systems deliver precision, speed, and seamless integration for complex projects while reducing on-site labor and errors. By combining efficiency with improved performance, DBC is setting new standards and expanding the possibilities of modern wall system design and construction. To assess and enhance such performance, DBC commissioned Sustainable Minds to conduct a life cycle assessment (LCA) of its X-Series panelized exterior wall systems.

This study evaluates two X-Series products: the exterior insulation and finish (EIFS) system and the metal composite material (MCM) system. Both systems share common layers, including steel framing and gypsum sheathing, but differ in the types of insulation, air and water resistive barriers, and exterior finishes. The EIFS system incorporates a drainage plane, base coat, expanded polystyrene (EPS) foam, mesh, primer, and finish coat. The MCM system features mineral wool, cladding support, and composite panels. The LCA was conducted in accordance with the relevant PCR and ISO standards, using a system boundary that includes production, product distribution, installation, and end-of-life.

A high-level summary of the study's findings is presented in the table below, showing environmental impacts per declared unit for both X-Series systems. Key indicators include CO_2-equivalent emissions, ozone depletion, ecotoxicity, and SM single score results. For additional impact categories and results for panels with openings, please refer to the full report. The results show that cradle-to-gate life cycle modules account for most of the life cycle impacts, largely due to upstream component production, including raw material extraction and manufacturing operations at the DBC facility. Several opportunities exist to reduce these impacts, including engaging suppliers that use lower-impact or recycled materials and integrate renewable energy can reduce upstream impacts. Within manufacturing, increasing renewable energy use, improving energy efficiency, and reducing or diverting scrap back into production may lower environmental impacts. These strategies provide actionable pathways for DBC to refine its sustainability approach, improve environmental performance, and enhance the robustness of its LCA.

X-Series: Panelized exterior wall system	Impact category	Unit	Production stage (A1-A3)	Construction stage (A4-A5)	End of life stage (C1-C4)	Total
Exterior insulation and finish (EIFS) system	*Global warming*	kg CO_2 eq	2.52E+03	4.46E+02	7.22E+01	**3.04E+03**
		%	82.96%	14.66%	2.38%	**100%**
	Ozone depletion	kg CFC-11 eq	9.56E-05	6.33E-06	1.31E-06	**1.03E-04**
		%	92.60%	6.13%	1.27%	**100%**
	Ecotoxicty	CTUe	2.93E+04	3.75E+03	5.84E+03	**3.89E+04**
		%	75.33%	9.64%	15.02%	**100%**
	SM single figure	mPts	1.11E+03	1.75E+02	6.45E+01	**1.35E+03**
		%	82.23%	12.98%	4.80%	**100%**
Metal composite materials (MCM) system	*Global warming*	kg CO_2 eq	3.46E+03	7.14E+02	1.09E+02	**4.28E+03**
		%	80.79%	16.67%	2.54%	**100%**
	Ozone depletion	kg CFC-11 eq	4.97E-05	1.00E-05	1.98E-06	**6.17E-05**
		%	80.52%	16.28%	3.21%	**100%**
	Ecotoxicty	CTUe	6.46E+04	4.82E+03	8.60E+03	**7.80E+04**
		%	82.79%	6.18%	11.03%	**100%**
	SM single figure	mPts	3.19E+03	2.07E+02	9.55E+01	**3.50E+03**
		%	91.35%	5.92%	2.73%	**100%**

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1 INTRODUCTION

1.1 Opportunity

Digital Building Components (DBC) is a manufacturer of panelized exterior wall systems and structural cold-formed metal framing, designed and built using advanced digital modeling and off-site manufacturing. Founded in 2016, DBC is advancing the way the industry builds by integrating precision engineering with a more streamlined construction process. Unlike traditional methods, DBC fabricates fully coordinated building systems in a controlled environment, reducing on-site labor, minimizing errors, and accelerating dry-in while providing schedule certainty and reducing the overall construction timeline. Their panelized exterior and structural framing solutions are tailored to meet the demands of complex projects where speed, accuracy, and integration are critical. With a focus on designing efficient, high-performance building systems, DBC is advancing the environmental and operational performance of construction projects. By leveraging digital workflows and sustainable off-site manufacturing, DBC helps reduce waste, improve quality, and enable faster, more predictable project delivery. These solutions reflect DBC's commitment to innovation, reliability, and building a smarter future for the construction industry.

As part of its ongoing commitment to environmental sustainability, DBC has embarked on a project to better understand the environmental impacts of its panelized exterior wall systems. To transparently communicate the potential environmental impacts and performance of these products, conducting a life cycle assessment (LCA) is essential to evaluate the potential impacts across all stages of the products' life, from raw material extraction and manufacturing to distribution, installation, and end-of-life disposal. The goal is to explore the potential environmental impacts that wall systems have and to identify ways to improve processes and reduce impacts.

To understand the true potential environmental impacts, DBC commissioned Sustainable Minds to help develop an LCA for its panelized exterior wall systems. DBC is looking forward to having guidance for future product improvements that can be informed by the results of this study.

DBC is also interested in having LCA data available for its panelized exterior wall systems to be able to obtain a Sustainable Minds Transparency Report [EPD]™ (TR), which is an ISO 14025 Type III [1] environmental declaration 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 14040/14044 [2], ISO 21930:2017 [3], Sustainable Minds Part A: LCA calculation rules and report requirements [4], and Sustainable Minds Part B for prefabricated exterior wall panel assemblies (v1) [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 over the 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 or 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), or cradle-to-grave (which includes all other stages including the use phase and disposal once the useful life is over).

Any LCA conducted with the intention of publishing EPDs needs to comply with the internationally accepted ISO 14040 and ISO 14040 standards. ISO 14040 provides principles and frameworks for conducting an LCA, while ISO14044 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.

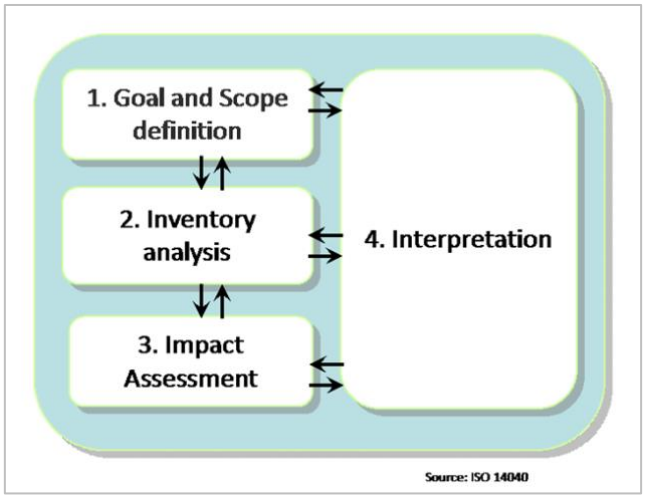


Figure 1. Phases of an LCA

- **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 declared 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 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 declared unit.

- **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 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 to ensure the reliability and robustness of the results. LCA, if well interpreted and evaluated, presents a number of opportunities for the manufacturer in developing sustainability goals and initiatives.

This LCA study follows an attributional approach and uses a system boundary that includes cradle-to-gate life cycle modules plus transport to the building sites, installation, and end-of-life. 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 from the project team led by Gayatri Umashankar, Prefab Integrator & Regional Business Development (Northwest & Southwest) at DBC, with support from Jason Roland (Plant Operations Manager), Colby Hinkson (Procurement Lead), and Matt Sullivan (Business Development Lead) during the data collection, reporting, and interpretation phases. Sustainable Minds led the development of the LCA results, LCA report, and Transparency Report [EPD]™.

1.4 Status

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

Primary data was collected to accurately represent manufacturing and supply chain operations for each wall system type over their respective production periods. Separate data collection forms were used for each wall system to ensure system-specific accuracy. The data covers the period from January 2023 through August 2024, capturing production activities for both wall system types. All data was sourced from DBC's manufacturing facility in Phoenix, Arizona. Where specific data points were unavailable, informed assumptions were made based on DBC's technical expertise. Background data sets were also used to complete the life cycle inventory and fill any remaining data gaps where necessary.

This is a supporting LCA report for the DBC Transparency Report [EPD]™ and was evaluated for conformance to the PCR according to the ISO 14025 and ISO 14040/14044 standards. The LCA review and verification of the Sustainable Minds Transparency Report [EPD]™ were carried out by Terrie Boguski, Harmony Environmental, LLC to determine conformance to ISO 14040/14044 and the relevant PCR.

2 GOAL AND SCOPE

This chapter explains the goal and scope of the 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 intends to define the specific application of the LCA methodology to the life cycle of the panelized exterior wall systems manufactured by DBC. 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 reviewer who will be assessing the LCA for conformance to the PCR, as well as DBC's internal stakeholders involved in marketing and communications, operations, and design. A third-party LCA report, excluding any confidential information, is planned to be made publicly available and linked to from the Transparency Report [EPD]™.

The results presented in this document are not meant to support comparative claims. The outcomes 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 (B2C).

2.2 Product description

Engineered-to-order exterior wall panel systems are configurable exterior façades using a variety of materials with optional integral windows. Digital Building Components offers a wide range of finish systems, effects, and textures with flexibility in panel sizes. DBC's finished exterior systems are best for increasing installation speed and quality, so that the building can be occupied faster than a traditional field-built system. The X-Series works for all building types, especially less-articulated projects with uniform openings. DBC offers three different types of X-Series exterior wall panel systems: EIFS (exterior insulation and finish system), MCM (metal composite materials), and IMP (insulated metal panels) systems. Only the EIFS and MCM systems have been evaluated in this study.

The X-Series EIFS system offers exterior wall insulation, water resistance, and a finished look, all integrated into a composite material. Designed to maximize water and thermal resistance, DBC's EIFS wall system is also cost effective, easy to install, fully furnished, and shipped to the site. The drainage plane is at the face of the air/water barrier. The bottom of the panel is back wrapped to allow moisture an exit pathway. Water-managed EIFS wall systems include an air/vapor barrier at the sheathing and a drainage plane, providing a redundant layer of protection and performance.

It is composed of multiple layers, each serving a distinct purpose: cold formed steel metal framing, exterior gypsum sheathing, air/water resistive barrier, EPS foam insulation, reinforcing mesh/base coat, and finish coat. The cold-formed steel frame provides structural strength and dimensional stability, ensuring precise integration with the building structure. Exterior gypsum sheathing adds a rigid, fire-resistant substrate and structural support, while the air and water resistive barrier prevents air infiltration and water intrusion to protect the building envelope and improve energy performance. EPS foam insulation delivers continuous thermal resistance, reducing heat transfer and enhancing overall efficiency. The reinforcing mesh and

base coat contribute durability, crack resistance, and impact protection, and the finish coat provides the desired architectural appearance while offering weather protection and UV resistance.

The X-Series MCM system is a factory-assembled rear-ventilated rainscreen system with fire-retardant core metal composite material (MCM), also known as aluminum composite material (ACM). The joints between MCM panels feature a spline. The MCM material is usually 4mm thick, composed of two sheets of metal sandwiching thermoplastic material.

It is composed of multiple integrated layers, each serving a distinct function: cold-formed steel framing, exterior gypsum sheathing, air and water resistive barrier, Z-girt, mineral wool insulation, hat channel, and MCM panel. The steel frame, sheathing, air and water resistive barrier, and insulation serve the same core functions as in the EIFS system, providing structural support, fire resistance, moisture protection, and thermal performance. Z-girts create a secure structural attachment point for both insulation and panels, while also facilitating effective water drainage and ventilation within the wall assembly. In certain designs, a hat channel is added to enhance structural support, improve ventilation, and ensure precise panel alignment. The exterior finish layer features aluminum composite material panels, which replace the multi-layer coating system used in EIFS to deliver superior weather resistance, long-term durability, and a modern, high-end architectural appearance.

Figure 2 provides representative product images for the panelized exterior wall systems evaluated in this study.

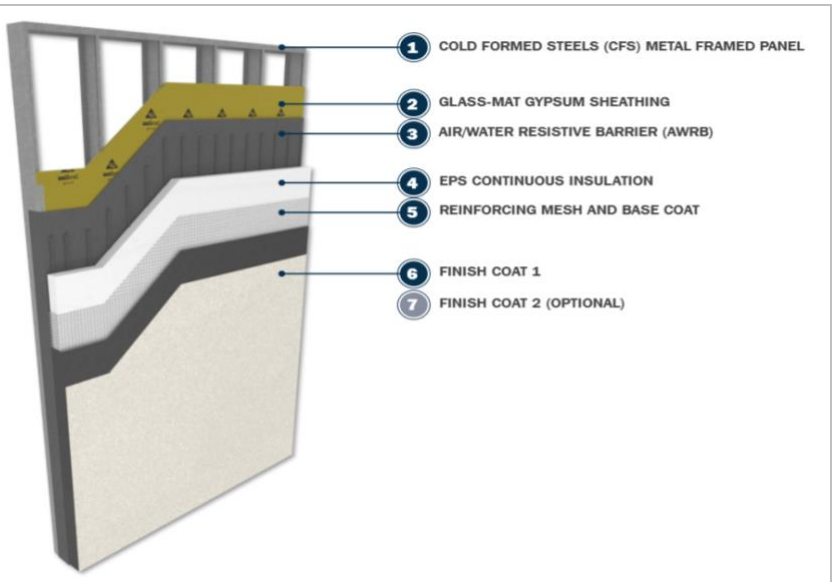
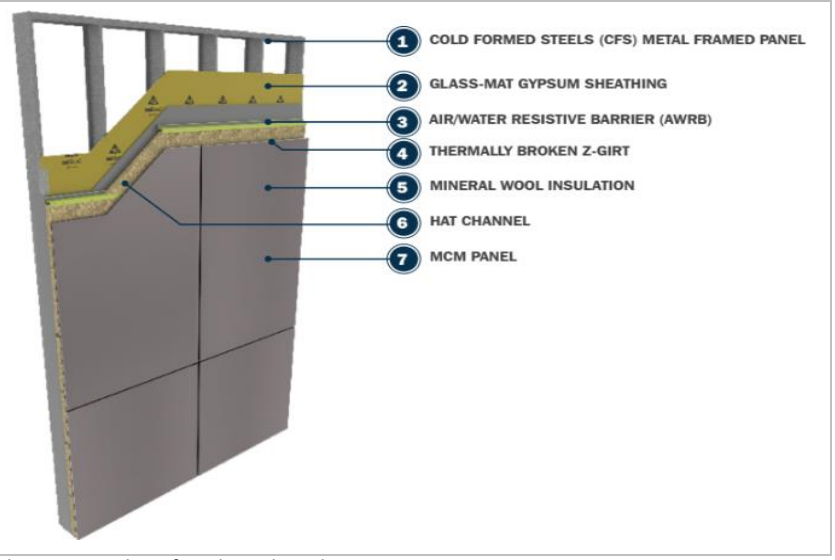
X-Series EIFS system	
X-Series MCM system	

Figure 2. Visual representation of evaluated products

Table 1 lists the product information in accordance with PCR, including the declaration name, products included in the declaration, CSI MasterFormat® classification, manufacturing location, and the type of declaration. Table 2 lists the declared product properties as prescribed by the PCR.

Table 1. Declared product information and type of declaration

Transparency Report [EPD]™ name	Product name	CSI MasterFormat® classification	Manufacturing location	Type of declaration
X-Series: Panelized Exterior Wall Systems	X-Series EIFS System	07 42 63	Phoenix, AZ	Product-specific, plant-specific declaration for one manufacturer
	X-Series MCM System			Product-specific, plant-specific declaration for one manufacturer

Table 2. Declared product properties

Properties	X-Series EIFS	X-Series MCM	Unit
Mass per declared unit	1,263	1,841	kg
Product thickness	0.270	0.295	m
Height and width of each panel	3.02 * 4.72 (typical panel size)		m
Product density	327	437	kg/m^3
Minimum span available	Min. width: 1.22 Min. height: 3.05	Min. width: 1.22 Min. height: 3.05	m
Maximum span available	Max. width: 4.11 Max. height: 10.7	Max. width: 4.11 Max. height: 10.7	m
Number of panels in one declared unit	2.60	2.60	
Panel RSI (total)	40.6	42.4	m^2.K/W
R-value of components filling up designated openings	1.23 (Windows)		m^2.K/W
% of openings (applicable only for results with openings)	11.8	15.1	%
Anticipated reference service life (RSL)	75		years

The structural performance and fire resistance properties of DBC's steel framing products are certified to comply with International Building Code (IBC) and International Residential Code (IRC), with the certification issued by IAPMO Uniform Evaluation Service. Health Product Declarations (HPD) are available for both X-Series EIFS and X-Series MCM systems. For more information about the products, including details about the materials that conform to the relevant standards, visit https://www.digitalbuilding.com/products/x-series.

2.3 Declared unit

This LCA evaluates the cradle-to-gate life cycle modules, plus transport to the building site, installation, and end of life for panelized exterior wall systems manufactured by DBC. According to the PCR, the declared unit is an installed wall system which covers 400 square feet of an exterior building. The mass per declared unit is 1,263 kg for the X-Series EIFS system, and 1,841 kg for the X-Series MCM system.

All necessary fasteners, clips, brackets, sealants, gaskets, and adhesives are included within the system boundaries. For each wall system type, results are disclosed for a solid wall without openings; however, separate results are also disclosed for panels incorporating openings. For panels with openings, all associated infill components are installed at the DBC facility, and their impacts are comprehensively included within the system boundary in accordance with the PCR.

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.

This LCA's system boundary is cradle-to-gate with options. The life cycle activities and related processes included are the life cycle stage modules from A1-A5 and C1-C4 as illustrated in Figure 3. This includes raw material extraction and preprocessing, transportation to the manufacturing facility, product manufacturing, distribution, installation, transport to waste disposal, and disposal at the end of the

service life. Table 3 lists specific inclusions and exclusions for the system boundary.

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

Figure 3. Applied system boundary

Table 3. System boundary inclusions and exclusions

Included	Excluded
• Raw material extraction for components • Transport of raw materials/components to the final product manufacturing facility • Processing of raw materials into components • Other inputs to the factory • Energy production • Manufacturing waste and its disposal • Packaging for the final product (material extraction, upstream processing, and its transport to the manufacturing facility) • Product transport to the building sites • Ancillary materials and energy usage during installation • Installation scrap and packaging waste disposal • Waste transport, processing, and disposal at the end-of-life	• Construction of major capital equipment • Manufacture of support equipment • Human labor and employee transport • Manufacturing facility air conditioning • Manufacture and transport of packaging materials not associated with final product • Product use

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 DBC facility. It includes three product life cycle modules:

- **Extraction and upstream production (A1)**
  - Extraction and processing of raw materials
  - Upstream production of system components
- **Transport to factory (A2)**
  - Transportation of components to the DBC manufacturing facility
- **Manufacturing (A3)**
  - Energy and water consumption for product manufacturing
  - Product packaging
  - 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

2.4.2 Construction stage (A4-A5)

The construction stage starts when the product is shipped from the DBC facility and ends once the product is installed at the building site. It includes two product life cycle modules:

- **Transport to site (A4)**
  - Product distribution to the building site
- **Installation (A5)**
  - Ancillary materials and energy usage required for installation
  - Disposal of product packaging and product scrap generated

2.4.3 End-of-life stage (C1-C4)

The end-of-life stage starts when the product reaches the end of its service life and ends once the product is disposed, reused, and/or recycled. It includes four life cycle modules:

- **Deconstruction/demolition (C1)**
  - Removal from the building
- **Transport to waste processing or disposal (C2)**
  - Shipment to waste processing centers
- **Waste processing (C3)**
  - Preparation of the product for waste prior to final disposal
- **Waste disposal (C4)**
  - Final product disposal: landfilling/reuse/recycling/recovery

Figure 4 provides an overview of the product flow during its life cycle.

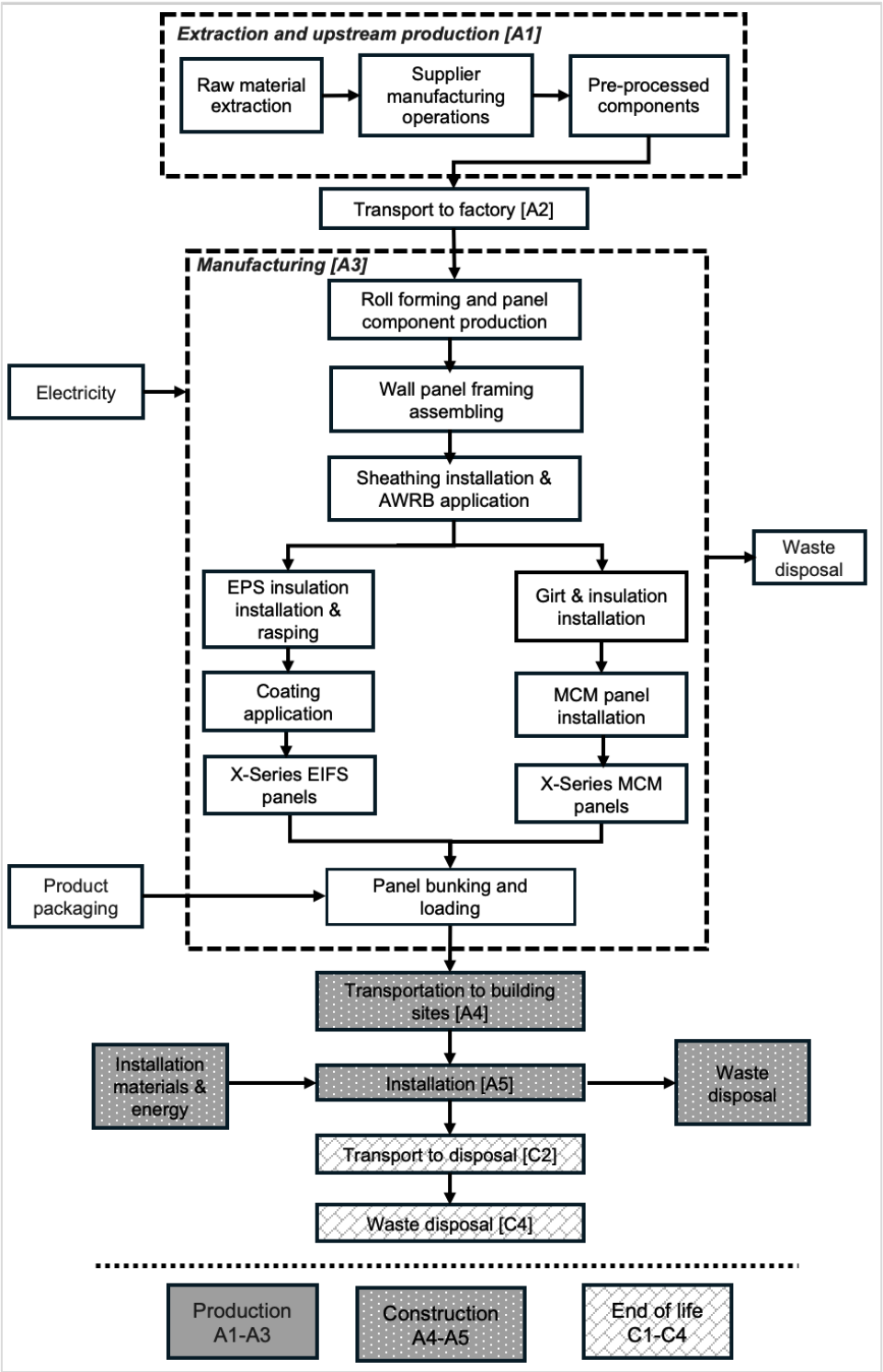


Figure 4. System boundary and product flow diagram of X-Series: Panelized Exterior Wall Systems

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 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 procedures

The data used for this study comprises a mix of primary data and background data. Primary data was collected directly from DBC and includes detailed information on the manufacturing processes, energy and material inputs, and on-site operations. For upstream or purchased components, data was obtained from existing EPDs wherever possible, providing transparent, product-specific environmental information. Where suitable EPDs were not available, assumptions for upstream processing were developed using input from DBC and supplemented with secondary resources such as published product documentation, publicly available technical specifications, and relevant industry reports. Background data was sourced from established life cycle inventory (LCI) databases to represent generic materials, processes, and energy sources, ensuring that all stages of the product system were consistently modeled. This combined approach enabled the integration of specific, high-quality primary data with credible secondary sources to address data gaps and maintain consistency throughout the assessment. 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.

Primary data provided by DBC represents the supply chain (A1-A2) and manufacturing operations (A3). Data was collected in a consistent manner and level of detail to ensure high-quality data. EPDs for upstream components, if available, were also provided by DBC. While the available upstream component EPDs conformed to their respective PCRs, separate component-level analyses were performed in this LCA using the data available within those EPDs or from other sources. Those component analyses were performed in accordance with SM Part A and do not necessarily conform to their respective PCRs. 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 DBC and their suppliers. Data representing both the supply chain and manufacturing operations were collected for the manufacturing facility in Phoenix, AZ. For the X-Series EIFS and X-Series MCM systems, data was gathered for a period of January 2023 through August 2024 to provide a more comprehensive representation of the operations and supply chain. A timeframe longer than twelve consecutive months was used to capture larger production rounds of both the EIFS and MCM systems in order to provide a more representative sample. The resulting inventory calculations were developed by an analyst at Sustainable Minds and subsequently checked internally.

The model was developed in SimaPro with consistency in mind. Expert judgment was used in selecting appropriate data sets to model the materials, material processing, and energy for this study and has been noted in the following sections. Databases adopted in the model include ecoinvent v3.11, Industry data 2.0, and US-EI 2.2 databases. Industry Data 2.0 is a SimaPro-integrated library compiling sector-specific LCA data from various industry associations. US-EI 2.2 is a U.S.-specific LCA inventory database providing production, energy, and emissions data

for U.S. industrial processes. In this study, US-EI 2.2 is used specifically for EPA e-grid electricity data sets.

3.2 Primary data

Primary data was collected from DBC to represent their operations and supply chain. This data was gathered through direct measurements or, when measurements were unavailable, based on engineering estimates provided by manufacturing facility personnel, reflecting actual production. While facility data was collected for all processes within DBC's control, assumptions were made to represent the material composition and processing required for the production of purchased components. These assumptions were either informed by the component EPDs where available, or via secondary resources and discussions with upstream suppliers about their facility operations and the components they supply to DBC.

3.2.1 Raw material extraction, upstream processing, & transport to factory (A1-A2)

These modules represent raw material extraction, preprocessing/upstream component production, and shipment to the manufacturing facility.

DBC provided detailed material composition data for all components of the panelized exterior wall systems, using either their own facility data or product documentation such as EPDs and product data sheets. These product systems do not contain hazardous substances according to the standards or regulations of the Resource Conservation and Recovery Act (RCRA), Subtitle C.

Primary supply chain data was also provided, detailing supplier locations, shipping distances, and transportation modes to the final manufacturing plant. Each material and component are sourced from a single supplier. While final assembly and some processing takes place at the DBC facility, all base components are pre-manufactured at the suppliers' facilities. These materials and components are then transported by truck to the DBC facility. Table 4 below summarizes the modeling approach used for each component, detailing material composition and processing.

Table 4. Assumptions used for modeling panelized exterior wall system components

Component	Material	Applicable system type	Upstream EPD and modeling assumptions
Cold formed steel (CFS) framing	Steel master coils	EIFS, MCM	Master coils are purchased and further processed at the DBC facility into framing components.
	Box stud insulation	EIFS, MCM	EPD for thermafiber mineral wool The material composition from the EPD was used. An existing ecoinvent data set for stone wool was modified to match the material composition with no changes to the manufacturing resources. Scrap was embedded in the data sets used.
	U channel	EIFS, MCM	EPD for steel framing and accessories The material composition from the EPD was used. Steel rolling, cutting, and bending operations were added to represent the upstream processing. Scrap was embedded in the data sets used.
Sheathing	Densglass gold sheathing	EIFS, MCM	EPD for gypsum from Georgia-Pacific The material composition from the EPD was used. An existing ecoinvent data set for gypsum plasterboard was modified to match the material composition with no changes to the manufacturing resources. Scrap was embedded in the data set used.
Fasteners		EIFS, MCM	No upstream EPD available A hot rolled steel rods data set and an average metal working data set from ecoinvent were used to represent the processing. A scrap rate of 5% was added.

Air and water resistive barrier (AWRB)	Diverter track	EIFS	EPD for HDS framing system The material composition from the EPD was used. Steel rolling and cutting operations were added to represent the upstream processing. Scrap was embedded in the data sets used.
	Sheathing fabric	EIFS	No upstream EPD available. Polyester fibers and PET were used as primary feedstock materials. An existing ecoinvent transformation data set for spunbonded nonwoven propylene textile was used to represent the upstream processing. A scrap rate of 5% was added in line with other fabric production processes.
	Senergy maxflash liquid	EIFS	No upstream EPD available. The material composition was manually developed using the safety data sheet for the product. Air and water resistive barriers were assumed to be made via minimal mixing, so no processing data sets were added. A minimal scrap rate of 1% was added.
	Senergy Senershield-R	EIFS	No upstream EPD available. The material composition was developed using the safety data sheet for the product. Air and water resistive barriers were assumed to made via minimal mixing, so no processing data sets were added. A minimal scrap rate of 1% was added.
	Vaproshield silicone sealant	MCM	No upstream EPD available. The material composition was developed using the safety data sheet for the product. A minimal scrap rate of 1% was added.
	Vaproshim SA self adhered	MCM	No upstream EPD available. The material composition was developed using the product data sheets (since the safety data sheet only disclosed the substances but not the mass share). A minimal scrap rate of 1% was added.
	Vaproshield blockflashing	MCM	No upstream EPD available. The material composition was developed using the safety data sheet for the product. A minimal scrap rate of 1% was added.
	Vaproshield panel shield SA	MCM	No upstream EPD available. The material composition was developed using the safety data sheet for the product. A minimal scrap rate of 1% was added.
EPS foam insulation	Insulfoam	EIFS	EPD for expanded polystyrene insulation The material composition from the EPD was used. An existing ecoinvent data set for polystyrene foam slab production was modified to match the material composition with no changes to the manufacturing resources. Scrap was embedded in the data set used.
Reinforcing mesh		EIFS	No upstream EPD available. An existing ecoinvent data set for glass wool mat was used directly with no changes made to the data set. Scrap was embedded in the data set used.
Cement		EIFS	EPD for Portland cement The material composition from the EPD was used. An existing ecoinvent data set for Portland cement production was modified to match the material composition with no changes to the manufacturing resources. Scrap was embedded in the data set used.
Windows *(only applicable for panels with openings)*	Window	EIFS, MCM	No upstream EPD available. Product documentation shows the use of recycled content in both aluminum (88.9% recycled) and glass (88.7%). This recycled content was included in the model. The share of aluminum frame and glazing unit (glass) in the window was gathered from an EPD for a similar window. The composition of the aluminum frame portion was gathered from an EPD for aluminum frame. Upstream processing of the aluminum frame was represented by an aluminium section bar extrusion data set available in ecoinvent. Material inputs and processing for the glazing unit was gathered from an EPD EPD for a Cascadia window.
	Window flashing	EIFS, MCM	No upstream EPD available. Low-alloyed steel was used as feedstock material, and steel rolling, cutting, and metal forming (bending) operations were added to represent the upstream processing. A scrap rate of 5% was added.
	Window shims	MCM	No upstream EPD available. A material composition of 100% polystyrene was assumed after internal discussions. Processing of the component was represented using injection molding of thermoplastics. A scrap rate of 5% was added.

Base coat	Senergy base coat	EIFS	No upstream EPD available. The material composition was developed using the safety data sheet for sto primer adhesive and the EPD for sto primer/adhesive. Paints and coatings were assumed to be made via minimal mixing, so no processing data sets were added. A minimal scrap rate of 1% was added.
Primer	Senergy primer	EIFS	No upstream EPD available. The material composition was developed using the EPD for primers by ISOMAT. Paints and coatings were assumed to be made via minimal mixing, so no processing data sets were added. A minimal scrap rate of 1% was added.
Finish coat	Senergy finish coat	EIFS	No upstream EPD available. The material composition was developed using two EPDs for other top coats available on market: the GAF acrylic top coat and Dulux ultra top coat. Paints and coatings were assumed to be made via minimal mixing, so no processing data sets were added. A minimal scrap rate of 1% was added.
Insulation and MCM support	Z-girt	MCM	EPD for greengirt The material composition data was sourced from the product EPD. Supplier documentation indicates 25% post-consumer and 7% pre-consumer recycled content; however, as no substance-level breakdown was available, a conservative estimate of 30% recycled content was applied to the entire product. Manufacturing resource data was also taken from the EPD, and product scrap was accounted for in the material composition calculations.
	Insulation washers & stick pins	MCM	No upstream EPD available. Low-alloyed steel was used as a feedstock material, and steel rolling, cutting, and metal forming (bending) operations were added to represent the upstream processing. A scrap rate of 5% was added.
	Insulation peel & press pins	MCM	No upstream EPD available. The material composition was assumed to be 85% low-alloyed steel and 15% rubber-based adhesive. Steel rolling, cutting, and metal forming (bending) operations were added to represent the upstream processing. A scrap rate of 5% was added.
MCM panel		MCM	EPD for alpolic metal composite panels The material composition from the EPD, including the packaging materials, was used. The secondary materials LCI indicator was used to calculate the recycled content for incoming materials. Manufacturing resources (electricity and energy) were copied from the existing USLCI+ data set for MCM sheets. Scrap rate was also calculated from the materials for recycling LCI indicator in the EPD.

Material composition and transportation data for panelized exterior wall systems are reported in Table 5 and
Table 6, respectively. These tables represent the inputs into the manufacturing process, and the composition of the final wall system will differ after manufacturing waste is accounted for. Final product packaging, including its extraction, manufacturing, and transport, is included in the manufacturing (A3) module per ISO 21930:2017.

Table 5. Raw material composition and packaging inputs per declared unit

Layer	Component / material	X-Series EIFS %WT	X-Series MCM %WT
Steel framing	Steel	20-27%	20-27%
Sheathing	Glass sheathing	30-34%	30-34%
Air and water resistive barrier (AWRB)	AWRB membranes	2-7%	2-7%
Air and water resistive barrier (AWRB)	Flashing	0%	<2%
Insulation	EPS insulation	3-15%	0%
Mesh & base coat	Base coat	5-10%	0%
Finish coat	Finish coat	5-10%	0%
Finish coat	Primer	1-4%	0%
Z girt	Z girt	0%	4-8%
Insulation	Mineral wool insulation	0%	3-15%
MCM panel	MCM panel	0%	10-14%
Product packaging	Wood blocks	4-7%	4-7%
Product packaging	Plywood board	3-5%	3-5%
Product packaging	Packing foam	1-2%	1-2%
Product packaging	Other packaging	<2%	<2%
All other components	-	1-2%	1-2%

Table 6. Supplier transportation distances by material and component
[Submitted to the reviewer]

3.2.2 Manufacturing (A3)

Both panelized exterior wall systems evaluated in this study are manufactured at the DBC facility in Phoenix, AZ. The systems are composed of multiple components sourced directly from upstream suppliers, which are processed and assembled into the final wall systems. In accordance with ISO 21930, the upstream extraction, processing, and production of purchased components are included in A1, while DBC's manufacturing and assembly activities are covered in A3.

The fabrication of the X-Series EIFS system begins with roll forming cold-formed steel coils into precise DBC stud and track profiles. These lightweight steel studs, tracks, and components are then welded and assembled into prefabricated wall frames and sections. Sheathing boards are installed over the frames to add structural support, enhance surface stability, and provide a base for subsequent layers. A liquid-applied air and water-resistive barrier is applied to the sheathing, creating a continuous protective layer that resists air and moisture infiltration. Expanded polystyrene foam insulation boards are then adhered over the barrier to provide thermal insulation and form a smooth base. These boards undergo rasping to refine the surface in preparation for finishing. Next, a base coat is applied over the insulation, with fiberglass mesh embedded within it to improve impact resistance and overall durability. Once the base coat cures, a primer is applied, followed by a textured finish coat that delivers weather protection, color, and architectural character.

The completed wall systems are then stacked and secured into organized bunks for efficient storage and transport. To safeguard them from moisture, dust, and potential damage, the bunks are tightly wrapped in shrink wrap. Finally, they are

carefully loaded and secured for shipping to ensure safe and reliable delivery to the job site. The overall manufacturing operations at the DBC facility for the X-Series EIFS system is summarized in the flow chart below. While this represents the production of a solid panel system, there are additional operations for panels with openings including cutting openings into the panels. Since the openings are pre-filled in the facility, the assembly of openings (like doors and windows) would also be added. Figure 5 provides a simplified flowchart of manufacturing operations at the DBC facility during the production of the X-Series EIFS system.

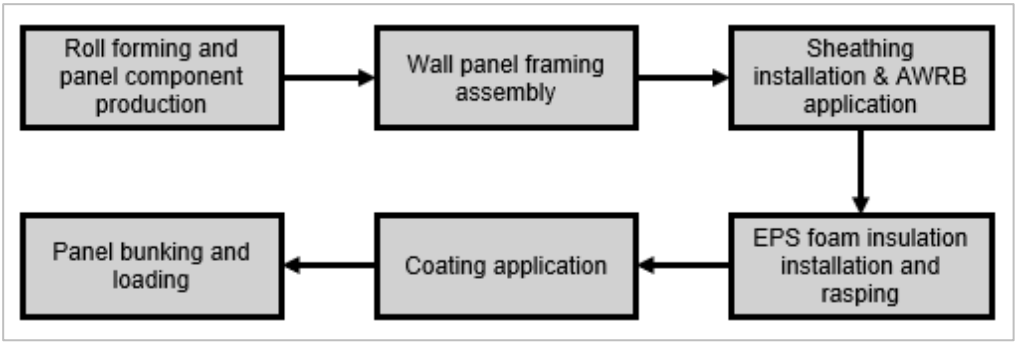


Figure 5. Manufacturing flowchart for X-Series EIFS system at DBC facility

For the X-Series MCM system, many of the manufacturing operations are similar to the EIFS system but with notable differences in the air and water resistive barrier and panel assembly. Instead of the liquid-applied AWRB used in the EIFS system, the MCM system incorporates a peel-and-stick barrier applied to the sheathing boards. This creates a seamless protective layer that prevents air and moisture infiltration into the building envelope. Horizontal Z-girts, made from a composite metal hybrid material, are then attached to the steel framing. These are specifically designed to minimize thermal bridging, thereby enhancing the building's overall energy efficiency. Semi-rigid exterior insulation boards are installed between the girts to meet thermal performance requirements.

Once the insulation is in place, prefabricated MCM panels are mounted onto panel clips fastened to the Z-girts, with joints aligned according to the prefab panel design. After installation, the wall systems undergo the same bunking, packaging, and loading processes as the EIFS system, preparing them for shipment to job sites. For the MCM systems with openings, additional operations are carried out, following procedures similar to those used for EIFS systems with openings. Figure 6 provides a simplified flowchart of manufacturing operations at the DBC facility during the production of the X-Series MCM system.

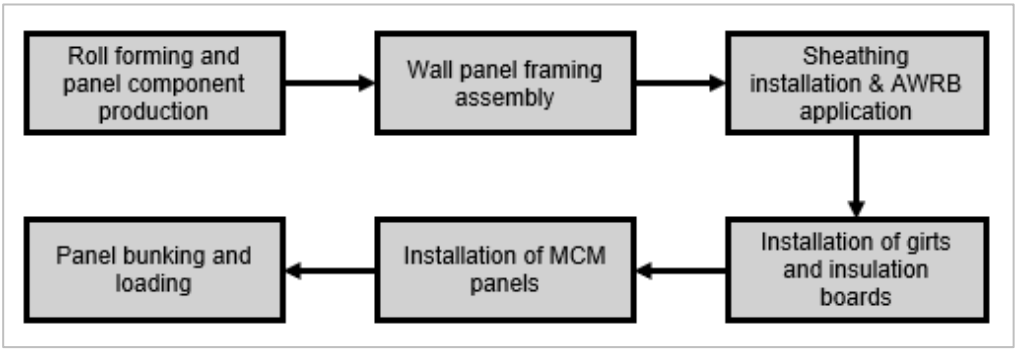


Figure 6. Manufacturing flowchart for X-Series MCM system at DBC facility

Both wall system types utilize the same packaging configuration. Primary data collected from multiple shipments indicate that each packaging bunk contains approximately 8,000 lbs of finished product, which was scaled to the declared unit

of 400 ft². The bunk incorporates several packaging materials, each serving a specific protective or structural function: wood blocks to stabilize and elevate the load, cardboard corner guards to protect edges from impact and abrasion, packing foam to cushion and reduce vibration during transport, shrink wrap to secure and consolidate the load, and plywood boards to provide structural rigidity and protect against puncture or compression.

Primary manufacturing data on electricity consumption and waste generation were collected for the period of January 2023 through August 2024. While data were available for a longer timeframe, only those relevant to the products included in this study were considered. Since multiple projects were in production during this period, total manufacturing resource use was allocated proportionally based on the square footage of wall systems produced.

DBC operates with on-site solar panels that are connected to the electricity grid. A portion of the facility's total energy demand is met by solar generation, while the remainder is supplied from the grid. The details regarding on-site solar panels are provided in Table 7.

Table 7. Details for on-site solar panels

Description	Details
Tracking system ID (SRP account number)	475-848-004
Renewable facility/generator owner	DBC
Renewable facility/generator location	Pheonix, AZ
Project vintage (build date)	2017
Project generation date (year first produced renewable energy)	2017
Nameplate capacity of the project	300 kW AC 367.20 kW DC
Utility to which the project is interconnected	Arizona-New Mexico (AZNM)

The use of a custom framing modeling software eliminates material waste, as the framing components are cut to accurate sizes. Excess materials are reused in other projects to avoid unnecessary scrap. Manufacturing waste streams include sheathing scrap, which is landfilled, and metal scrap, which is typically recycled or reused. However, in the absence of detailed, material-specific waste data, all waste was assumed to be landfilled. A landfill distance of 32.2 km was assumed. Data on landfill hauling provided by DBC were allocated using the same square-footage approach as described above. Resource inputs (energy and ancillary materials) and outputs (waste streams) during manufacturing are listed in Table 8.

Table 8. Manufacturing inputs and waste per declared unit

Resource category	Flow	Unit	X-Series EIFS	X-Series MCM
Energy	Grid electricity	kWh	[redacted]	[redacted]
	Solar electricity	kWh	[redacted]	[redacted]
	Total	**kWh**	[redacted]	[redacted]
Manufacturing waste (100% landfilled)		kg	[redacted]	[redacted]
Waste transport		km	32.2	

3.2.3 Product distribution (A4)

This module refers to the transport and delivery of wall systems from the manufacturing facility to the site where they are installed and used.

DBC's panelized exterior wall panel systems are shipped directly from the manufacturing facility to the job site. Primary data for specific projects were used to report weighted average shipping distances. Product distribution parameters are reported in Table 9.

Table 9. Panelized exterior wall system distribution parameters per declared unit

Name	X-Series EIFS	X-Series MCM	Unit
Fuel type	Diesel		
Vehicle type	Class 8 truck		
Liters of fuel	6.74	9.68	l/100km
Transport distance	951	1,315	km
Capacity utilization (including empty runs, mass based)	100		%
Weight of products transported	1,623	2,331	kg

3.2.4 Product installation (A5)

This module represents the installation of the wall systems, making them ready for use.

Installation services are managed separately by contractors. At the manufacturing facility, panels are cut to size based on customer-provided field measurements, which minimizes installation waste for end users. As a result, installation is typically straightforward, requiring little to no modification of shipped materials. The drilling of holes during installation has not been included in this study, as the associated energy use is expected to be negligible. Therefore, the only energy needed is for moving and lifting panels, and a 0% product installation scrap rate is assumed. A crane is used to place panels onto building walls, and DBC provided data on diesel consumption for crane operations from separate projects installing the X-Series EIFS and MCM systems. The only waste generated is packaging from shipping. Shrink wrap is disposed of in landfills, while all other packaging materials are returned to DBC for reuse. A transportation distance of 32.2 km was assumed for shrink wrap disposal.

For the X-Series EIFS system, primary data on total ancillary materials used during installation was provided. DBC indicated that ancillary materials used for installation would be the same per declared unit of both EIFS and MCM systems. Product installation parameters are reported in Table 10.

Table 10. Panelized exterior wall system installation parameters per declared unit

Name		X-Series EIFS	X-Series MCM	Unit
Installation product scrap rate assumed		0		%
Ancillary materials	Backer rods	1.94		kg
	Silicone sealant	17.5		kg
	Cement board	22.1		kg
	Clips, connectors, and fasteners	12.9		kg
Diesel usage (for crane operation)		6.12	10.3	liter

Product loss per declared unit (installation scrap)		0	kg
Waste materials at the construction site before waste processing, generated by product installation (installation scraps & packaging waste)		238	kg
Distance to disposal of waste materials		20	mi
Mass of packaging waste specified by type	Cardboard guards	7.05	kg
	Plywood board	74.0	kg
	Packing foam	31.7	kg
	Shrink wraps	15.9	kg
	Wood blocks	109	kg
Biogenic carbon contained in packaging		349	kg CO_2
Direct emissions to ambient air, soil, and water		0	kg

3.2.5 Deconstruction/demolition (C1)

This module represents the dismantling or demolition of the product from the building, including any associated energy use. It was assumed that the panelized exterior wall systems reach the end of their service life concurrently with the building and are removed during the overall demolition process. As energy and material inputs for this stage are considered negligible, no additional environmental impacts are attributed to the deconstruction of the wall system at the end of its service life.

3.2.6 Transport to waste processing or disposal (C2)

This module covers the transportation of discarded products to a waste processing site for final disposal. The waste transportation distance for all panelized exterior wall systems is assumed to be 32.2 km, with transport conducted using diesel-powered trucks.

3.2.7 Waste processing (C3)

This module represents the processing of waste generated, resulting in materials for reuse, secondary materials, and secondary fuels. It is assumed that no waste processing is needed before the waste is sent to landfill.

3.2.8 Waste disposal (C4)

This module represents the final waste disposal including the physical treatment and management of the disposal site. The wall systems are assumed to be sent to either a construction or inert waste landfill. End of life activity inputs are reported in Table 11. Processes specific to each material type were selected where available.

Table 11. Panelized exterior wall system end of life parameters per declared unit

Name		X-Series EIFS	X-Series MCM	Unit
Collection process	Collected separately	0		kg
	Collected with mixed construction waste	1,263	1,841	kg
Recovery (by type)	Landfill (100%)	1,263	1,841	kg
Waste transport		32.2		km
Removal of biogenic carbon (excluding packaging)		0		kg CO_2

3.3 Background data

This section details the background data sets used for modeling all relevant activities associated with the life cycle of DBC panelized exterior wall systems. Each table includes the data set name, database, reference year, and geographic region. The LCA model was developed using SimaPro Craft 10.2. Life cycle inventory data for the raw materials and processes involved in modeling the products were sourced from the ecoinvent v3.11, US-EI 2.2, and Industry Data 2.0 databases. Data sets older than 10 years were chosen because they closest represent the technology used and are assumed to be more accurate than other potential proxies with more precise geography or temporal representativeness.

3.3.1 Materials

A model for each individual component was developed based on its material composition, with appropriate data sets for each raw material selected from the background databases. In cases where country-specific data were unavailable, global or rest-of-world averages were used to represent production in those regions. Table 12 lists the most relevant LCI data sets used in modeling the raw materials.

Table 12. Key material data sets used in inventory analysis

Data set(s)	Database	Technology	Reference year	Geography
Steel cold rolled coil {GLO} | blast furnace route and electric arc furnace route | production mix, at plant | 1kg, typical thickness between 0.15 - 3 mm. typical width between 600 - 2100 mm | LCI result	Industry data 2.0	Appropriate technology	2021	Global
Stone wool {RoW}| stone wool production | Cut-off, U Blast furnace slag {RoW}| market for blast furnace slag | Cut-off, U Feldspar {GLO}| market for feldspar | Cut-off, U Gravel, crushed {RoW}| market for gravel, crushed | Cut-off, U Phenolic resin {RoW}| market for phenolic resin | Cut-off, U Urea {RoW}| market for urea | Cut-off, U	ecoinvent v3.11	Appropriate technology	2010*	Rest of World
Steel, low-alloyed {GLO}| market for steel, low-alloyed | Cut-off, U Zinc coat, pieces {RoW}| zinc coating, pieces | Cut-off, U Electricity mix 2021/US US-EI U	ecoinvent v3.11	Appropriate technology	2011*	US
Gypsum fibreboard {RoW}| gypsum fibreboard production | Cut-off, U Gypsum, mineral {RoW}| market for gypsum, mineral | Cut-off, U Glass fibre {GLO}| market for glass fibre | Cut-off, U	ecoinvent v3.11	Appropriate technology	2010*	Rest of World

Steel, billets, at plant {RNA} | Steel, billets, at plant Zinc coat, pieces {RoW}| zinc coating, pieces | Cut-off, U Metal working, average for steel product manufacturing {RoW}| metal working, average for steel product manufacturing | Cut-off, U	ecoinvent v3.11	Appropriate technology	2013*	North America
Fibre, polyester {GLO}| market for fibre, polyester | Cut-off, U Polyethylene terephthalate, granulate, amorphous {GLO}| market for polyethylene terephthalate, granulate, amorphous | Cut-off, U Acrylic dispersion, with water, in 58% solution state {RER}| market for acrylic dispersion, with water, in 58% solution state | Cut-off, U Textile, nonwoven polypropylene {RoW}| textile production, nonwoven polypropylene, spunbond | Cut-off, U	ecoinvent v3.11	Appropriate technology	2018	Rest of World
Polystyrene foam slab {RoW}| polystyrene foam slab production | Cut-off, U (inclusive of feedstock materials and polymer foaming process)	ecoinvent v3.11	Appropriate technology	2010*	Rest of world
Glazing, double, U<1.1 W/m2K {GLO}| market for glazing, double, U<1.1 W/m2K | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Global
Aluminium, primary, ingot {RoW}| market for aluminium, primary, ingot | Cut-off, U Tin {GLO}| market for tin | Cut-off, U Steel, low-alloyed {GLO}| market for steel, low-alloyed | Cut-off, U Polypropylene, granulate {GLO}| market for polypropylene, granulate | Cut-off, U Section bar extrusion, aluminium {RoW}| section bar extrusion, aluminium | Cut-off, U (for metals) Extrusion, plastic pipes {RoW}| extrusion, plastic pipes | Cut-off, U (for plastics)	ecoinvent v3.11	Appropriate technology	2012*	Rest of world
Silica sand {GLO}| market for silica sand | Cut-off, U Tap water {RoW}| market for tap water | Cut-off, U Acrylic dispersion, with water, in 58% solution state {RoW}| market for acrylic dispersion, with water, in 58% solution state | Cut-off, U Chemical, organic {GLO}| market for chemical, organic | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Global
Acrylic dispersion, with water, in 58% solution state {RoW}| market for acrylic dispersion, with water, in 58% solution state | Cut-off, U Tap water {RoW}| market for tap water | Cut-off, U Calcium carbonate, precipitated {RoW}| market for calcium carbonate, precipitated | Cut-off, U Vinyl acetate {RoW}| market for vinyl acetate | Cut-off, U Chemical, organic {GLO}| market for chemical, organic | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Rest of World
Tap water {RoW}| market for tap water | Cut-off, U Silica sand {GLO}| market for silica sand | Cut-off, U Acrylic dispersion, with water, in 58% solution state {RoW}| market for acrylic dispersion, with water, in 58% solution state | Cut-off, U Titanium dioxide {RoW}| market for titanium dioxide | Cut-off, U Chemical, organic {GLO}| market for chemical, organic | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Rest of World
Glass fibre reinforced plastic, polyamide, injection moulded {GLO}| market for glass fibre reinforced plastic, polyamide, injection moulded | Cut-off, U Steel, low-alloyed {GLO}| market for steel, low-alloyed | Cut-off, U Polyester resin, unsaturated {RoW}| market for polyester resin, unsaturated | Cut-off, U Aluminium hydroxide {GLO}| market for aluminium hydroxide | Cut-off, U Polystyrene, high impact {GLO}| market for polystyrene, high impact | Cut-off, U Electricity, medium voltage, at grid, 2021/US US-EI U	ecoinvent v3.11	Appropriate technology	2011*	US

Metal composite material (MCM) sheet, at plant {RNA} | Metal composite material (MCM) sheet, at plant Aluminum, sheet, coated, at plant {RNA} | Aluminum, sheet, coated, at plant Polyethylene, low density, granulate {GLO}| market for polyethylene, low density, granulate | Cut-off, U Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U Sawnwood, softwood, dried (u=10%), planed {RoW}| market for sawnwood, softwood, dried (u=10%), planed | Cut-off, U	ecoinvent v3.11	Appropriate technology	2015	North America
Corrugated board box {US}| market for corrugated board box | Cut-off, U	ecoinvent v3.11	Appropriate technology	2023	US
Plywood {RoW}| market for plywood | Cut-off, U	ecoinvent v3.11	Appropriate technology	2020	Rest of World
Polystyrene, expandable {GLO}| market for polystyrene, expandable | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Global
Packaging film, low density polyethylene {GLO}| market for packaging film, low density polyethylene | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Global
Sawnwood, softwood, dried (u=10%), planed {RoW}| market for sawnwood, softwood, dried (u=10%), planed | Cut-off, U	ecoinvent v3.11	Appropriate technology	2023	Rest of World

*Data sets older than 10 years were chosen because they closest represent the technology used to manufacture the material and are assumed to be more accurate than other potential proxies with more precise geography and temporal representativeness. For manually modeled upstream components, the reference year and geographic region of the base material with the largest mass share were used.

3.3.2 Transportation

Raw materials and components are transported to the DBC manufacturing facility mainly via flatbed trucks. Transportation data sets account for load factors, which represent an average of empty and fully loaded conditions, including empty backhauls. Data sets for each transportation mode were sourced from the available databases. US-specific transportation data were used when available; otherwise, generic global data sets were applied. Table 13 shows the most relevant LCI data sets used in modeling transportation.

Table 13. Transportation data sets used in inventory analysis

Data set	Database	Technology	Reference year	Geography
Transport, freight, lorry 16-32 metric ton, EURO6 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U	ecoinvent v3.11	Appropriate technology	2014*	Rest of World
Municipal waste collection service by 21 metric ton lorry {GLO}| market for municipal waste collection service by 21 metric ton lorry | Cut-off, U	ecoinvent v3.11	Appropriate technology	2012*	Global

*Data sets older than 10 years were chosen because they closest represent the technology used to manufacture the material and are assumed to be more accurate than other potential proxies with more precise geography and temporal representativeness.

3.3.3 Energy and upstream processing

Since the DBC facility is located in Arizona, electricity consumption at the site was modeled using the most recent eGRID data set for the AZNM (Arizona-New Mexico) subregion. To accurately capture the upstream processing of purchased components, relevant data sets from ecoinvent v3.11 were selected to be representative of both the material processed and the associated manufacturing operations. For electricity consumed during these upstream processes, the generic U.S. electricity mix was applied, providing a consistent and representative basis for the assessment across all supply chain activities. Table 14 shows the most relevant LCI data sets used in modeling energy and upstream processing.

Table 14. Key energy and upstream data sets used in inventory analysis

Data set	Database	Technology	Reference year	Geography
Electricity mix, eGrid subregion, AZNM/US U	US-EI 2.2 + EPA	Appropriate technology	2023	AZ, USA
Electricity, production mix photovoltaic, at plant/US US-EI U	US-EI 2.2	Appropriate technology	2018	US
Electricity mix 2021/US US-EI U	US-EI 2.2 + EPA	Appropriate technology	2023	US
Metal working, average for steel product manufacturing {RoW}| metal working, average for steel product manufacturing | Cut-off, U	ecoinvent v3.11	Appropriate technology	2023	Rest of World
Sheet rolling, steel {RoW}| sheet rolling, steel | Cut-off, U	ecoinvent v3.11	Appropriate technology	2023	Rest of World
Injection moulding {RoW}| injection moulding | Cut-off, U	ecoinvent v3.11	Appropriate technology	2020	Rest of World
Section bar extrusion, aluminium {RoW}| section bar extrusion, aluminium | Cut-off, U	ecoinvent v3.11	Appropriate technology	2024	Rest of World
Extrusion, plastic pipes {RoW}| extrusion, plastic pipes | Cut-off, U	ecoinvent v3.11	Appropriate technology	2024	Rest of World
Wire drawing, steel {RoW}| wire drawing, steel | Cut-off, U	ecoinvent v3.11	Appropriate technology	2011*	Rest of World
Blow moulding {RoW}| blow moulding | Cut-off, U	ecoinvent v3.11	Appropriate technology	2020	Rest of World

*Data sets older than 10 years were chosen because they closest represent the technology used to manufacture the material and are assumed to be more accurate than other potential proxies with more precise geography and temporal representativeness.

3.3.4 Disposal

Processes specific to waste types were selected to correspond to the disposal of facility waste streams. Table 15 lists the relevant disposal data sets used in the model.

Table 15. Key disposal data sets used in inventory analysis

Data set	Database	Technology	Reference year	Geography
Inert waste {RoW}| treatment of inert waste, sanitary landfill | Cut-off, U	ecoinvent v3.11	Appropriate technology	2024	Rest of World
Waste plastic, mixture {RoW}| treatment of waste plastic, mixture, sanitary landfill | Cut-off, U	ecoinvent v3.11	Appropriate technology	2023	Rest of World
Waste glass {GLO}| treatment of waste glass, sanitary landfill | Cut-off, U	ecoinvent v3.11	Appropriate technology	2024	Global

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 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 mass and energy 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 have to 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. While some recycled materials are used in the upstream production of components, there are no recycled materials used within the DBC facility. The recycled materials come burden free to the product system. There were no co-products manufactured. The allocation procedures used in background data sets were accepted without modification.

The DBC facility produces multiple types of wall systems each year. Allocation of manufacturing resources was performed proportionally to the total square footage produced for each system type. Square footage was selected as the allocation metric because it best represents the manufacturing effort, capturing material throughput and processing time for all product types made at the facility.

This approach aligns with ISO 21930:2017, which requires allocation based on physical relationships when they provide the most representative and transparent basis for distributing inputs and outputs. By using production area as the allocation parameter, this study ensures relevance, transparency, and accuracy in impact attribution across product systems.

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

3.6 Discussion of data quality

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

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from the ecoinvent v3.11, US-EI 2.2, and Industry data 2.0 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 v3.11, US-EI 2.2, and Industry data 2.0 databases with documented precision to the extent available.

- *Completeness*: Sustainable Minds worked with DBC and its suppliers to obtain a comprehensive set of primary data associated with the manufacturing processes and material compositions. 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 DBC 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 from January 2023 through August 2024, ensuring the representativeness of the manufacturing process. Secondary data were obtained from the ecoinvent v3.11, US-EI 2.2, and Industry data 2.0 databases and are typically representative of recent years. Temporal representativeness is therefore considered to be good.

- *Geographical*: Primary data are representative of production in Phoenix, AZ. Secondary data were collected specific to the country under study. Where country-specific data were unavailable, global or rest-of-world averages were used to represent production in those locations. Geographical representativeness is therefore considered to be very good.

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

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 this study should be recognized:

- Primary data were modeled based on information provided by DBC for specific projects under consideration. However, upstream supply chain data are subject to variability, which may impact the accuracy of the results.
- Upstream suppliers were contacted to obtain EPDs, product documentation, and details on component processing (e.g., manufacturing activities, waste handling, and scrap rates). Not all suppliers were able to provide this information, and assumptions were applied in those cases. Results may differ if primary data were collected directly from upstream facilities.
- For components with existing EPDs, LCIA results could not be directly applied due to differences in impact assessment methods, disclosed categories, and database or software versions. Raw material compositions and upstream processes were modeled with secondary data sets, with some manual adjustments for consistency; results may have differed if upstream primary data had been available.
- For components lacking existing EPDs, material compositions were developed using proxies such as similar EPDs or safety data sheets, and upstream processes were modeled entirely with secondary data. Results may have differed if actual upstream facility data had been collected.
- While the results presented correspond to specific colors and finishes, the panelized wall systems are available in a wide range of color and texture options. These variations may result in minor differences in impacts, but they were assumed to be negligible.
- Impacts from installation re-work were assumed to be negligible. About 3% of panels required on-site modifications (e.g., additional cuts for lights or auxiliary boxes, per DBC), but since panels were otherwise factory pre-cut, this was the only source of installation scrap. The associated on-site energy use for these modifications and material waste from these adjustments were therefore assumed to be zero.
- While multiple projects of the same system type were running concurrently in the manufacturing facility, electricity consumption was allocated proportionally to each system type based on square-foot production. Minor variations between individual projects of the same system type may exist, which could introduce uncertainty from the allocation.
- For manufacturing facility waste, granular data on waste streams was not available; therefore, all waste was assumed to be landfilled. In practice, some materials (e.g., metals and plastics) are recycled at the waste processing facility. This landfilling assumption represents a conservative approach to modeling disposal of manufacturing waste.
- Generic data sets were used for material inputs, transportation, and waste processing, which are considered to be of good quality. However, actual impacts from material suppliers, transport carriers, and local waste processing may vary, potentially affecting the accuracy of the results.
- 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.
- While on-site renewable energy generation has been accounted for in this study, 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 16). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.2 classification and characterization [7]. Long-term emissions (>100 years) are not taken into consideration in the impact estimate. TRACI 2.2 uses GWP factors based on the IPCC Fourth Assessment Report (AR4, 2007). Although the IPCC Sixth Assessment Report (AR6, 2021) provides updated values, TRACI 2.2 has not incorporated them. Using AR4 values ensures consistency with the chosen methodology and comparability with other studies, while noting that results may differ slightly if AR6 factors were applied. USEtox indicators[2] are used to evaluate toxicity-related impact categories, namely ecotoxicity, carcinogenics, and non-carcinogenics. Emissions from waste disposal are considered part of the product system under study, according to the "polluter pays principle".

Table 16. 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 cause 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.
Freshwater eutrophication	kg P eq	This is a measure of the potential for nutrient enrichment of freshwater bodies (lakes, rivers, reservoirs) due primarily to phosphorus emissions. Excess nutrient inputs stimulate excessive algal growth, leading to oxygen depletion and degradation of aquatic ecosystems.
Marine eutrophication	kg N eq (nitrogen)	This refers to the potential for nutrient enrichment in marine and coastal waters, largely driven by nitrogen emissions. Elevated nitrogen levels can cause harmful algal blooms, hypoxia, and biodiversity loss in marine environments.
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 cause 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.

With respect to global warming potential, biogenic carbon is included in impact category calculations. The biogenic carbon measured in this study originates from packaging materials, and none of the raw materials used in the panelized exterior

[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/

wall systems are expected to contain biogenic carbon. 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. 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 17 conforming to the SM 2013 Methodology were applied. The SM 2013 Methodology uses TRACI 2.1 impact categories developed by U.S. EPA [10], and North American normalization and weighting values developed by 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 SM 2013 Methodology Report [6].

Table 17. 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 for calculating the ISO 21930:2017 metrics [11]. 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 [12]. Abiotic depletion potential was calculated using the CML impact assessment methodology [13]. 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, upstream processing, 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. On-site solar electricity was used in production in addition to the renewable energy accounted for in the 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 actual facility activities and the assumptions mentioned in the PCR. Waste treatments included within the system boundary are reported. All waste is landfilled at the end of life. Table 18 represents all the resource use and waste flow indicators, with the acronyms used, evaluated in this study.

Table 18. Resource use and waste flow indicators

Indicators	Acronyms used
Resource use indicators	
Renewable primary energy used as energy carrier (fuel)	**RPR_E**
Renewable primary resources with energy content used as material	**RPR_M**
Total use of renewable primary resources with energy content	**RPR_{total}**
Non-renewable primary resources used as an energy carrier (fuel)	**$NRPR_E$**
Non-renewable primary resources with energy content used as material	**$NRPR_M$**
Total use of non-renewable primary resources with energy content	**$NRPR_{total}$**
Secondary materials	**SM**
Renewable secondary fuels	**RSF**
Non-renewable secondary fuels	**NRSF**
Recovered energy	**RE**
Use of net fresh water resources	**FW**
Abiotic depletion potential for fossil resources	**ADPf**
Output flows and waste category indicators	
Hazardous waste disposed	**HWD**
Non-hazardous waste disposed	**NHWD**
High-level radioactive waste, conditioned, to final repository	**HLRW**
Intermediate- and low-level radioactive waste, conditioned, to final repository	**ILLRW**
Components for re-use	**CRU**
Materials for recycling	**MR**
Materials for energy recovery	**MER**
Exported energy	**EE**
Carbon emissions and removals	
Biogenic Carbon Removal from Product	**BCRP**
Biogenic Carbon Emission from Product	**BCEP**
Biogenic Carbon Removal from Packaging	**BCRK**
Biogenic Carbon Emission from Packaging	**BCEK**
Carbon Emission from Combustion of Waste from Renewable Sources Used in Production Processes	**CBCEW**
Calcination Carbon Emissions	**CCE**
Carbonation Carbon Removals	**CCR**
Carbon Emissions from Combustion of Waste from Non-Renewable Sources used in Production Processes	**CWNR**

Resource use, output flows, waste categories, and carbon emissions & removals for each panelized exterior wall system type have been tabulated in the sections below.

5.2.1 X-Series EIFS

Table 19 show resource use, output and waste flows, and carbon emissions and removals for the X-Series EIFS system per declared unit. Table 20 reports the same for the X-Series EIFS system with openings.

Table 19. Resource use, output and waste flows, and carbon emissions and removals for X-Series EIFS system per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Resource use indicators												
RPR_E	MJ, LHV	1.20E+03	2.59E+00	7.34E+03	6.31E+00	1.28E+02	MND	0	1.29E+00	0	2.23E+00	**8.68E+03**
RPR_M	MJ, LHV	4.24E+00	0	0	0	0	MND	0	0	0	0	**4.24E+00**
RPR_{total}	MJ, LHV	1.20E+03	2.59E+00	7.34E+03	6.31E+00	1.28E+02	MND	0	1.29E+00	0	2.23E+00	**8.68E+03**
$NRPR_E$	MJ, LHV	2.41E+04	1.31E+03	8.67E+03	3.19E+03	2.53E+03	MND	0	7.04E+02	0	2.85E+02	**4.08E+04**
$NRPR_M$	MJ, LHV	2.34E+03			0	5.88E+02	MND	0	0	0	0	**2.93E+03**
$NRPR_{total}$	MJ, LHV	2.64E+04	1.31E+03	8.67E+03	3.19E+03	3.12E+03	MND	0	7.04E+02	0	2.85E+02	**4.37E+04**
SM	kg	4.23E+00	0	0	0	0	MND	0	0	0	0	**4.23E+00**
RSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
NRSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
RE	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
FW	m^3	2.50E+03	1.20E+01	1.04E+03	2.93E+01	4.71E+02	MND	0	5.33E+00	0	1.50E+01	**4.07E+03**
ADPf	MJ, LHV	2.55E+04	1.31E+03	7.40E+03	3.18E+03	3.00E+03	MND	0	7.02E+02	0.	2.83E+02	**4.14E+04**
Output flows and waste category indicators												
HWD	kg	8.16E-01	1.36E-02	4.62E-01	3.31E-02	1.45E-01	MND	0	5.20E-03	0	5.97E-02	**1.53E+00**
NHWD	kg	4.59E+01	1.08E-01	1.25E+02	2.64E-01	1.28E+01	MND	0	2.03E-02	0	1.26E+03	**1.45E+03**
HLRW	kg	2.58E-03	1.80E-05	3.60E-03	4.38E-05	4.92E-04	MND	0	9.08E-06	0	1.10E-05	**6.75E-03**
ILLRW	kg	6.58E-03	3.78E-05	8.20E-03	9.20E-05	1.24E-03	MND	0	1.95E-05	0	2.62E-05	**1.62E-02**
CRU	kg	0	0	0	0	2.23E+02	MND	0	0	0	0	**2.23E+02**
MR	kg	1.58E+01	0	0	0	0	MND	0	0	0	0	**1.58E+01**
MER	kg	2.64E-06	0	0	0	2.50E+00	MND	0	0	0	0	**2.50E+00**
EE	MJ	0	0	0	0	0	MND	0	0	0	0	**0**
Carbon emissions and removals												
BCRP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCEP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCRK	kg CO_2	-1.74E-01	0	-3.49E+02	0	0	MND	0	0	0	0	**-3.49E+02**
BCEK	kg CO_2	0	0	1.74E-01	0	3.49E+02	MND	0	0	0	0	**3.49E+02**
CBCEW	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CCE	kg CO_2	7.70E+00	0	0	0	0	MND	0	0	0	0	**7.70E+00**
CCR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CWNR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**

Table 20. Resource use, output and waste flows, and carbon emissions and removals for X-Series EIFS system (with openings) per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Resource use indicators												
RPR_E	MJ, LHV	1.21E+03	2.63E+00	7.57E+03	6.18E+00	1.45E+02	MND	0	1.26E+00	0	2.17E+00	**8.94E+03**
RPR_M	MJ, LHV	3.74E+00	0	0	0	0	MND	0	0	0	0	**3.74E+00**
RPR_{total}	MJ, LHV	1.22E+03	2.63E+00	7.57E+03	6.18E+00	1.45E+02	MND	0	1.26E+00	0	2.17+00	**8.94E+03**
$NRPR_E$	MJ, LHV	2.43E+04	1.33E+03	9.12E+03	3.12E+03	2.83E+03	MND	0	6.86E+02	0	2.78E+02	**4.17E+04**
$NRPR_M$	MJ, LHV	2.07E+03			0	6.66E+02	MND	0	0	0	0	**2.73E+03**
$NRPR_{total}$	MJ, LHV	2.64E+04	1.33E+03	9.12E+03	3.12E+03	3.49E+03	MND	0	6.86E+02	0	2.78E+02	**4.44E+04**
SM	kg	3.43E+01	0	0	0	0	MND	0	0	0	0	**3.43E+01**
RSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
NRSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
RE	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
FW	m^3	1.96E+03	8.52E+00	9.66E+02	2.00E+01	3.92E+02	MND	0	4.17E+00	0	7.63E+00	**3.36E+03**
ADPf	MJ, LHV	2.54E+04	1.33E+03	7.72E+03	3.11E+03	3.36E+03	MND	0	6.84E+02	0	2.75E+02	**4.19E+04**
Output flows and waste category indicators												
HWD	kg	1.14E+00	1.38E-02	4.64E-01	3.24E-02	1.64E-01	MND	0	5.07E-03	0	5.76E-02	**1.88E+00**
NHWD	kg	4.68E+01	1.10E-01	1.42E+02	2.58E-01	1.45E+01	MND	0	1.97E-02	0	1.23E+03	**1.43E+03**
HLRW	kg	2.76E-03	1.83E-05	3.99E-03	4.28E-05	5.58E-04	MND	0	8.84E-06	0	1.07E-05	**7.39E-03**
ILLRW	kg	6.89E-03	3.84E-05	9.07E-03	9.00E-05	1.40E-03	MND	0	1.90E-05	0	2.56E-05	**1.75E-02**
CRU	kg	0	0	0	0	2.33E+02	MND	0	0	0	0	**2.23E+02**
MR	kg	1.40E+01	0	0	0	0	MND	0	0	0	0	**1.40E+01**
MER	kg	2.33E-06	0	0	0	2.50E+00	MND	0	0	0	0	**2.50E+00**
EE	MJ	0	0	0	0	0	MND	0	0	0	0	**0**
Carbon emissions and removals												
BCRP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCEP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCRK	kg CO_2	-1.54E-01	0	-3.49E+02	0	0	MND	0	0	0	0	**-3.49E+02**
BCEK	kg CO_2	0	0	1.54E-01	0	3.49E+02	MND	0	0	0	0	**3.49E+02**
CBCEW	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CCE	kg CO_2	6.80E+00	0	0	0	0	MND	0	0	0	0	**6.80E+00**
CCR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CWNR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**

5.2.2 X-Series MCM

Table 21 show resource use, output and waste flows, and carbon emissions and removals for the X-Series MCM system declared unit. Table 22 reports the same for the X-Series MCM system with openings.

Table 21. Resource use, output and waste flows, and carbon emissions and removals for X-Series MCM system per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Resource use indicators												
RPR_E	MJ, LHV	1.79E+03	6.99E+00	6.47E+03	1.25E+01	1.29E+02	MND	0	1.88E+00	0	3.25E+00	**8.42E+03**
RPR_M	MJ, LHV	1.76E+02	0	0	0	0	MND	0	0	0	0	**1.76E+02**
RPR_{total}	MJ, LHV	1.97E+03	6.99E+00	6.47E+03	1.25E+01	1.29E+02	MND	0	1.88E+00	0	3.25E+00	**8.59E+03**
$NRPR_E$	MJ, LHV	2.91E+04	3.53E+03	9.05E+03	6.33E+03	2.93E+03	MND	0	1.03E+03	0	4.15E+02	**5.24E+04**
$NRPR_M$	MJ, LHV	3.36E+03			0	5.88E+02	MND	0	0	0	0	**3.95E+03**
$NRPR_{total}$	MJ, LHV	3.24E+04	3.53E+03	9.05E+03	6.33E+03	3.12E+03	MND	0	1.03E+03	0	4.15E+02	**5.63E+04**
SM	kg	7.39E+02	0	0	0	0	MND	0	0	0	0	**7.39E+02**
RSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
NRSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
RE	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
FW	m^3	2.71E+03	2.26E+01	9.47E+02	4.05E+01	3.49E+02	MND	0	6.23E+00	0	1.14E+01	**4.09E+03**
ADPf	MJ, LHV	3.08E+04	3.52E+03	7.70E+03	6.32E+03	3.40E+03	MND	0	1.02E+03	0.	4.12E+02	**5.32E+04**
Output flows and waste category indicators												
HWD	kg	1.03E+00	3.66E-02	4.71E-01	6.57E-02	1.55E-01	MND	0	7.58E-03	0	8.65E-02	**1.85E+00**
NHWD	kg	4.88E+01	2.92E-01	2.56E+02	5.24E-01	1.42E+01	MND	0	2.95E-02	0	1.84E+03	**2.16E+03**
HLRW	kg	4.20E-03	4.84E-05	3.84E-03	8.69E-05	4.98E-04	MND	0	1.32E-05	0	1.60E-05	**8.71E-03**
ILLRW	kg	1.09E-02	1.02E-04	8.75E-03	1.83E-04	1.25E-03	MND	0	2.84E-05	0	3.82E-05	**2.13E-02**
CRU	kg	6.48E+01	0	0	0	2.23E+02	MND	0	0	0	0	**2.88E+02**
MR	kg	2.44E+02	0	0	0	0	MND	0	0	0	0	**2.44E+02**
MER	kg	0	0	0	0	2.50E+00	MND	0	0	0	0	**2.50E+00**
EE	MJ	0	0	0	0	0	MND	0	0	0	0	**0**
Carbon emissions and removals												
BCRP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCEP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCRK	kg CO_2	-8.49E+00	0	-3.49E+02	0	0	MND	0	0	0	0	**-3.57E+02**
BCEK	kg CO_2	0	0	8.49E+00	0	3.49E+02	MND	0	0	0	0	**3.57E+02**
CBCEW	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CCE	kg CO_2	1.13E+01	0	0	0	0	MND	0	0	0	0	**1.13E+01**
CCR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CWNR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**

Table 22. Resource use, output and waste flows, and carbon emissions and removals for X-Series MCM system (with openings) per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Resource use indicators												
RPR_E	MJ, LHV	1.69E+03	6.35E+00	6.63E+03	1.17E+01	1.51E+02	MND	0	1.74E+00	0	3.00E+00	**8.49E+03**
RPR_M	MJ, LHV	1.49E+02	0	0	0	0	MND	0	0	0	0	**1.49E+02**
RPR_{total}	MJ, LHV	1.84E+03	6.35E+00	6.63E+03	1.17E+01	1.51E+02	MND	0	1.74E+00	0	3.00E+00	**8.64E+03**
$NRPR_E$	MJ, LHV	2.86E+04	3.21E+03	9.71E+03	5.91E+03	3.26E+03	MND	0	9.49E+02	0	3.84E+02	**5.21E+04**
$NRPR_M$	MJ, LHV	2.85E+03			0	6.92E+02	MND	0	0	0	0	**3.54E+03**
$NRPR_{total}$	MJ, LHV	3.15E+04	3.21E+03	9.71E+03	5.91E+03	3.95E+03	MND	0	9.49E+02	0	3.84E+02	**5.56E+04**
SM	kg	6.67E+02	0	0	0	0	MND	0	0	0	0	**6.67E+02**
RSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
NRSF	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
RE	MJ, LHV	0	0	0	0	0	MND	0	0	0	0	**0**
FW	m^3	2.64E+03	2.05E+01	1.03E+03	3.78E+01	4.10E+02	MND	0	5.77E+00	0	1.06E+01	**4.15E+03**
ADPf	MJ, LHV	2.99E+04	3.20E+03	8.16E+03	5.89E+03	3.82E+03	MND	0	9.46E+02	0	3.81E+02	**5.23E+04**
Output flows and waste category indicators												
HWD	kg	1.25E+00	3.33E-02	4.75E-01	6.13E-02	1.71E-01	MND	0	7.01E-03	0	7.93E-02	**2.08E+00**
NHWD	kg	4.59E+01	2.65E-01	3.01E+02	4.89E-01	1.46E+01	MND	0	2.73E-02	0	1.70E+03	**2.07E+03**
HLRW	kg	4.08E-03	4.40E-05	4.41E-03	8.10E-05	5.84E-04	MND	0	1.22E-05	0	1.48E-05	**9.22E-03**
ILLRW	kg	1.04E-02	9.25E-05	1.00E-02	1.70E-04	1.47E-03	MND	0	2.63E-05	0	3.54E-05	**2.22E-02**
CRU	kg	5.50E+01	0	0	0	2.23E+02	MND	0	0	0	0	**2.78E+02**
MR	kg	2.07E+02	0	0	0	0	MND	0	0	0	0	**2.07E+02**
MER	kg	0	0	0	0	2.50E+00	MND	0	0	0	0	**2.50E+00**
EE	MJ	0	0	0	0	0	MND	0	0	0	0	**0**
Carbon emissions and removals												
BCRP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCEP	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
BCRK	kg CO_2	-7.22E+00	0	-3.49E+02	0	0	MND	0	0	0	0	**-3.56E+02**
BCEK	kg CO_2	0	0	7.22E+00	0	3.49E+02	MND	0	0	0	0	**3.56E+02**
CBCEW	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CCE	kg CO_2	9.58E+00	0	0	0	0	MND	0	0	0	0	**9.58E+00**
CCR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**
CWNR	kg CO_2	0	0	0	0	0	MND	0	0	0	0	**0**

5.3 Life cycle impact assessment (LCIA)

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

Life cycle impact assessment (LCIA) results are shown per declared unit of both product system types. Results are presented separately for solid panels and panels with openings for both types. 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 2.2 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.2) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM 2013 Methodology is also applied to TRACI 2.1 results 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.

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

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

5.3.1 X-Series EIFS

The LCIA results for the X-Series EIFS system per declared unit are shown in Table 23. The percent contribution of each associated life cycle module is tabulated in Table 24 and is also presented in Figure 7.

The product’s life cycle impacts are primarily driven by the cradle-to-gate modules A1, A2, and A3, which together account for the majority of the environmental burdens. Among these modules, A1, which includes the extraction of raw materials and the upstream production of wall system components delivered to the DBC facility, dominates most impact categories. For ecotoxicity, however, A3 is the

leading contributor. A3 encompasses all manufacturing operations at the DBC facility, with impacts primarily influenced by electricity use, landfilling of manufacturing waste, and sourcing of packaging materials for final product packaging. Electricity consumption and packaging materials are the main contributors to A3's global warming potential (GWP), while waste landfilling is a key driver of eutrophication and ecotoxicity impacts.

Following A1 and A3, the next most significant contributors are A4, which represents product distribution, and A5, which represents installation. A4 impacts are influenced by transportation distances between the manufacturing facility and installation sites. The longer the shipping distance, the greater the contribution to total impacts. A5 impacts stem mainly from the use of ancillary materials, including sealants and fasteners, and from diesel consumption associated with crane operations for lifting and positioning panels at the installation sites.

Table 23. Life cycle impact assessment results for X-Series EIFS system per declared unit

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	kg CFC-11 eq	8.46E-05	1.35E-06	9.58E-06	3.30E-06	3.03E-06	MND	0	8.64E-07	0	3.30E-07	**1.03E-04**
Global warming	kg CO2 eq	1.94E+03	9.87E+01	4.86E+02	2.41E+02	2.05E+02	MND	0	5.39E+01	0	1.20E+01	**3.03E+03**
Smog	kg O3 eq	7.99E+01	1.97E+00	2.61E+01	4.79E+00	1.28E+01	MND	0	8.06E+00	0	2.19E+00	**1.36E+02**
Acidification	kg SO2 eq	6.51E+00	1.37E-01	1.69E+00	3.34E-01	6.93E-01	MND	0	2.61E-01	0	1.19E-01	**9.74E+00**
Carcinogenics	CTUh	3.49E-04	2.55E-06	2.15E-05	6.21E-06	5.84E-05	MND	0	9.40E-08	0	2.79E-06	**4.41E-04**
Non carcinogenics	CTUh	3.03E-04	1.59E-05	2.98E-04	3.88E-05	4.99E-05	MND	0	2.56E-06	0	1.56E-04	**8.65E-04**
Respiratory effects	kg PM2.5 eq	9.28E-01	3.05E-02	2.49E-01	7.42E-02	1.34E-01	MND	0	3.28E-02	0	1.41E-02	**1.46E+00**
Ecotoxicity	CTUe	1.27E+04	3.62E+02	1.63E+04	8.83E+02	2.87E+03	MND	0	1.33E+01	0	5.31E+03	**3.84E+04**
Freshwater eutrophication	kg P eq	1.75E-01	4.13E-03	1.65E-01	1.01E-02	5.33E-02	MND	0	1.91E-04	0	1.32E-02	**4.21E-01**
Marine eutrophication	kg N eq	7.13E-01	1.71E-02	2.65E-01	4.17E-02	9.20E-02	MND	0	6.75E-02	0	2.03E-02	**1.22E+00**

End-of-life modules, particularly C2, which represents the transportation of waste to disposal facilities, and C4, which represents disposal and landfilling, also contribute noticeably to the overall life cycle results. These impacts are more significant in categories such as smog formation, which results from emissions during waste transport, and non-carcinogenic and ecotoxicity impacts, which result from landfilling processes.

Overall, A1 and A3 are the most impactful modules of the product life cycle. Their dominance is driven by two main factors: the upstream production and processing of raw materials and components, and the electricity required for manufacturing operations at the facility. While other life cycle modules contribute to environmental impacts, their influence is relatively minor in comparison.

Table 24. Percent contributions of life cycle modules for X-Series EIFS system

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	%	82.01%	1.31%	9.28%	3.20%	2.93%	MND	0	0.84%	0	0.32%	**100%**
Global warming	%	63.72%	3.25%	15.99%	7.92%	6.74%	MND	0	1.78%	0	0.39%	**100%**
Smog	%	58.38%	1.44%	19.07%	3.50%	9.39%	MND	0	5.93%	0	1.61%	**100%**
Acidification	%	66.59%	1.40%	17.25%	3.42%	7.09%	MND	0	2.68%	0	1.22%	**100%**
Carcinogenics	%	79.18%	0.58%	4.87%	1.41%	13.25%	MND	0	0.02%	0	0.63%	**100%**
Non carcinogenics	%	34.46%	1.81%	33.91%	4.41%	5.67%	MND	0	0.30%	0	18.04%	**100%**
Respiratory effects	%	63.27%	2.08%	16.95%	5.06%	9.14%	MND	0	2.24%	0	0.96%	**100%**
Ecotoxicity	%	32.59%	0.93%	41.81%	2.27%	7.37%	MND	0	0.03%	0	13.85%	**100%**
Freshwater eutrophication	%	41.45%	0.98%	39.05%	2.39%	12.63%	MND	0	0.05%	0	3.15%	**100%**
Marine eutrophication	%	58.22%	1.40%	21.62%	3.40%	7.51%	MND	0	5.55%	0	1.67%	**100%**

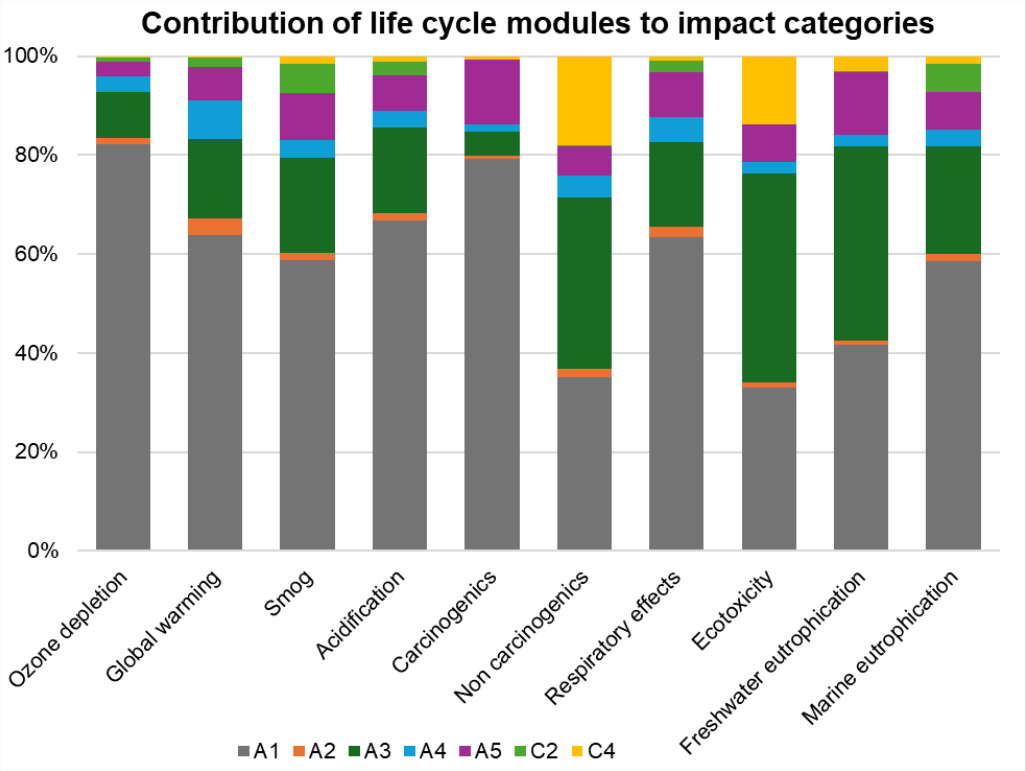


Figure 7. Contribution analysis of impact categories for X-Series EIFS system

The SM2013 Methodology single figure millipoint (mPt) score by life cycle module for this product is presented in Table 25. The raw material extraction and upstream production module (A1) dominates the results (~66%), followed by the manufacturing module (~16%).

Table 25. SM millipoint scores for X-Series EIFS system per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
SM single figure score	mPts	8.85E+02	1.18E+01	2.10E+02	2.87E+01	1.46E+02	MND	0	2.51E+00	0	5.63E+01	**1.34E+03**

A detailed evaluation of global warming potential (GWP) was conducted to understand the product's potential kg CO_2 equivalent emissions. As discussed earlier, module A1 is the largest contributor to total GWP (~64%), followed by module A3 (~16%). Modules A4 and A5 also account for a notable share of emissions, while the remaining life cycle stages contribute relatively little, as illustrated in Figure 8. A more granular analysis of module A1 was performed to determine the GWP contribution of individual material layers. This analysis shows that more than half of the GWP from A1 is attributed to the cold-formed steel framing layer (~55%). The other layers together make up the remaining share, with no single layer approaching the impact level of the framing.

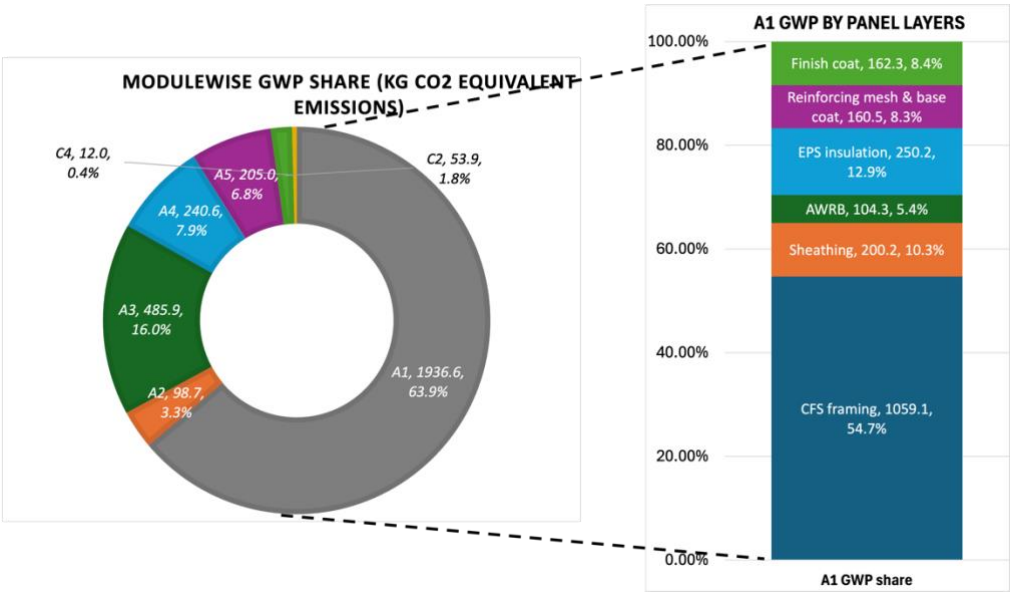


Figure 8. Module wise evaluation of GWP and breakdown by panel layers

5.3.2 X-Series EIFS (with openings)

The LCIA results for the X-Series EIFS system (with openings) per declared unit are shown in Table 26. The percent contribution of each associated life cycle module is tabulated in Table 27 and is also presented in Figure 9.

The product's life cycle impacts are primarily driven by the cradle-to-gate modules A1, A2, and A3, which together account for the majority of the environmental burdens. Among these modules, A1, which includes the extraction of raw materials, and the upstream production of wall system components delivered to the DBC facility, dominates all impact categories. A3 encompasses all manufacturing operations at the DBC facility, with impacts primarily influenced by electricity use, landfilling of manufacturing waste, and sourcing of packaging materials for final product packaging. Electricity consumption and packaging materials are the main contributors to A3's global warming potential (GWP), while waste landfilling is a key driver of eutrophication and ecotoxicity impacts.

Following A1 and A3, the next most significant contributors are A4, which represents product distribution, and A5, which represents installation. A4 impacts are influenced by transportation distances between the manufacturing facility and installation sites. The longer the shipping distance, the greater the contribution to total impacts. A5 impacts stem mainly from the use of ancillary materials, including sealants and fasteners, and from diesel consumption associated with crane operations for lifting and positioning panels at the installation sites.

Table 26. Life cycle impact assessment results for X-Series EIFS system (with openings) per declared unit

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	kg CFC-11 eq	7.61E-05	1.38E-06	1.03E-05	3.23E-06	3.39E-06	MND	0	8.42E-07	0	3.21E-07	**9.55E-05**
Global warming	kg CO2 eq	1.98E+03	1.00E+02	5.17E+02	2.35E+02	2.30E+02	MND	0	5.25E+01	0	1.16E+01	**3.12E+03**
Smog	kg O3 eq	8.16E+01	2.00E+00	2.69E+01	4.69E+00	1.38E+01	MND	0	7.85E+00	0	2.14E+00	**1.39E+02**
Acidification	kg SO2 eq	6.57E+00	1.39E-01	1.76E+00	3.27E-01	7.62E-01	MND	0	2.54E-01	0	1.15E-01	**9.93E+00**
Carcinogenics	CTUh	8.82E-04	2.59E-06	2.22E-05	6.07E-06	6.62E-05	MND	0	9.15E-08	0	2.94E-06	**9.82E-04**
Non carcinogenics	CTUh	4.90E-04	1.62E-05	3.30E-04	3.79E-05	5.65E-05	MND	0	2.49E-06	0	1.49E-04	**1.08E-03**
Respiratory effects	kg PM2.5 eq	1.05E+00	3.10E-02	2.53E-01	7.26E-02	1.49E-01	MND	0	3.19E-02	0	1.36E-02	**1.60E+00**
Ecotoxicity	CTUe	2.48E+04	3.68E+02	1.83E+04	8.64E+02	3.25E+03	MND	0	1.30E+01	0	5.08E+03	**5.27E+04**
Freshwater eutrophication	kg P eq	1.94E-01	4.20E-03	1.83E-01	9.85E-03	6.04E-02	MND	0	1.86E-04	0	1.24E-02	**4.64E-01**
Marine eutrophication	kg N eq	7.31E-01	1.74E-02	2.77E-01	4.08E-02	9.79E-02	MND	0	6.58E-02	0	1.96E-02	**1.25E+00**

End-of-life modules, particularly C2, which represents the transportation of waste to disposal facilities, and C4, which represents disposal and landfilling, also contribute noticeably to the overall life cycle results. These impacts are more significant in categories such as smog formation, which results from emissions during waste transport, and non-carcinogenic and ecotoxicity impacts, which result from landfilling processes.

Overall, A1 and A3 are the most impactful modules of the product life cycle. Their dominance is driven by two main factors: the upstream production and processing of raw materials and components, and the electricity required for manufacturing operations at the facility. While other life cycle modules contribute to environmental impacts, their influence is relatively minor in comparison.

Table 27. Percent contributions of life cycle modules for X-Series EIFS system (with openings)

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	%	79.58%	1.44%	10.73%	3.38%	3.54%	MND	0	0.88%	0	0.34%	**100%**
Global warming	%	63.15%	3.21%	16.53%	7.52%	7.34%	MND	0	1.68%	0	0.37%	**100%**
Smog	%	58.34%	1.43%	19.19%	3.35%	9.86%	MND	0	5.65%	0	1.54%	**100%**
Acidification	%	65.93%	1.40%	17.68%	3.28%	7.65%	MND	0	2.56%	0	1.16%	**100%**
Carcinogenics	%	89.78%	0.26%	2.26%	0.62%	6.74%	MND	0	0.01%	0	0.30%	**100%**
Non carcinogenics	%	44.69%	1.47%	30.09%	3.46%	5.15%	MND	0	0.23%	0	13.75%	**100%**
Respiratory effects	%	65.34%	1.93%	15.81%	4.53%	9.28%	MND	0	2.00%	0	0.85%	**100%**
Ecotoxicity	%	46.72%	0.69%	34.36%	1.62%	6.11%	MND	0	0.02%	0	9.63%	**100%**
Freshwater eutrophication	%	41.68%	0.90%	39.35%	2.12%	12.99%	MND	0	0.04%	0	2.67%	**100%**
Marine eutrophication	%	58.13%	1.38%	22.03%	3.24%	7.78%	MND	0	5.26%	0	1.57%	**100%**

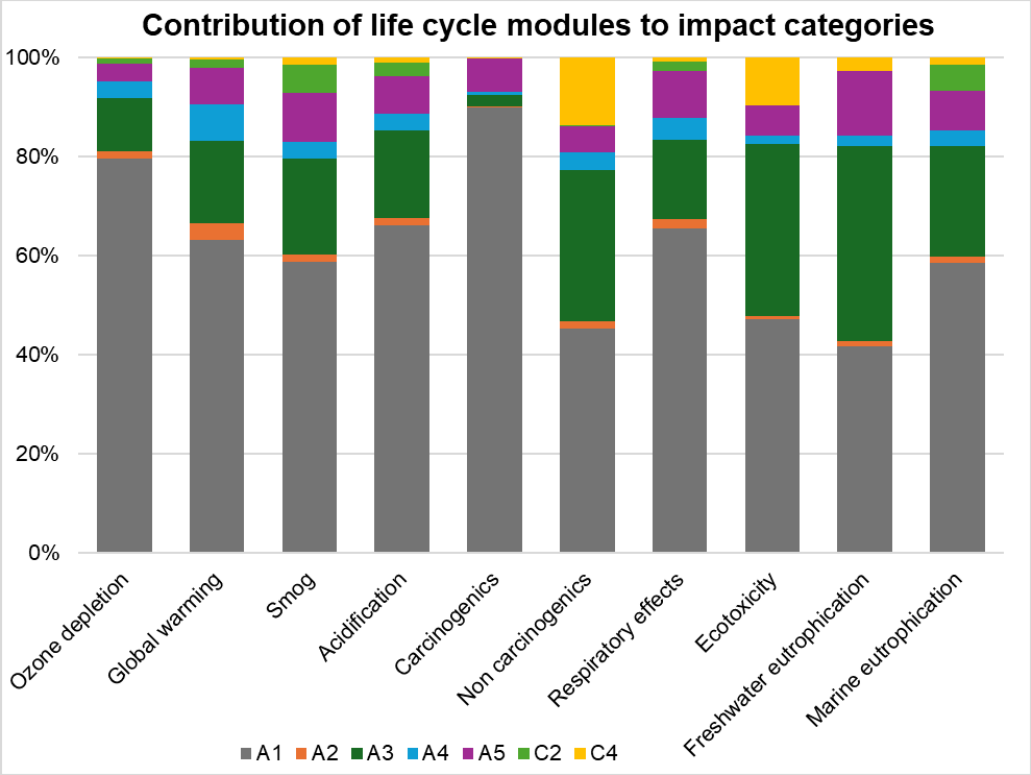


Figure 9. Contribution analysis of impact categories for X-Series EIFS system (with openings)

The SM2013 Methodology single figure millipoint (mPt) score by life cycle module for this product is presented in Table 28. The raw material extraction and upstream production module (A1) dominates the results (~80%), followed by the manufacturing module (~9%).

Table 28. SM millipoint scores for X-Series EIFS system (with openings) per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
SM single figure score	mPts	1.99E+03	1.20E+01	2.31E+02	2.81E+01	1.65E+02	MND	0	2.45E+00	0	5.43E+01	**2.49E+03**

A detailed evaluation of global warming potential (GWP) was conducted to understand the product's potential kg CO2 equivalent emissions. As discussed earlier, module A1 is the largest contributor to total GWP (~63%), followed by module A3 (~17%). Modules A4 and A5 also account for a notable share of emissions, while the remaining life cycle stages contribute relatively little, as illustrated in Figure 10. A more granular analysis of module A1 was performed to determine the GWP contribution of individual material layers. This analysis shows that more than half of the GWP from A1 is attributed to the cold-formed steel framing layer (~54%). The other layers together make up the remaining share, with no single layer approaching the impact level of the framing. Windows and openings make up ~6% of the A1 GWP, which was absent in the solid panels.

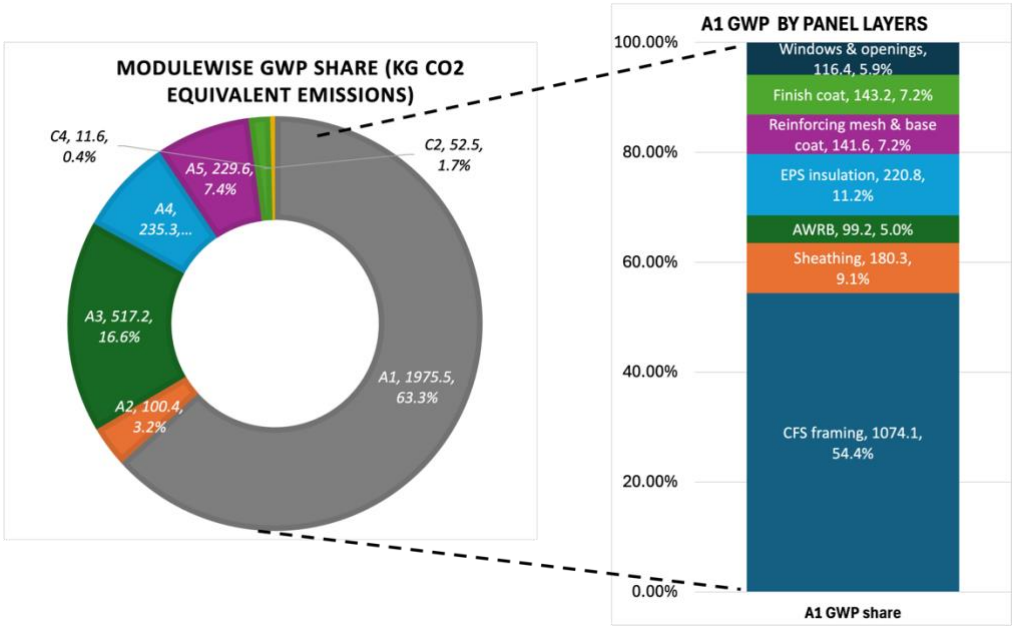


Figure 10. Module wise evaluation of GWP and breakdown by panel layers

5.3.3 X-Series MCM

The LCIA results for the X-Series MCM system per declared unit are shown in Table 29. The percent contribution of each associated life cycle module is tabulated in Table 30 and is also presented in Figure 11.

The product's life cycle impacts are primarily driven by the cradle-to-gate modules A1, A2, and A3, which together account for the majority of the environmental burdens. Among these modules, A1, which includes the extraction of raw materials, and the upstream production of wall system components delivered to the DBC facility, dominates most impact categories. For ecotoxicity and freshwater eutrophication, however, A3 is the leading contributor. A3 encompasses all manufacturing operations at the DBC facility, with impacts primarily influenced by electricity use, landfilling of manufacturing waste, and sourcing of packaging materials for final product packaging. Electricity consumption and packaging materials are the main contributors to A3's global warming potential (GWP), while waste landfilling is a key driver of eutrophication and ecotoxicity impacts.

Following A1 and A3, the next most significant contributors are A4, which represents product distribution, and A5, which represents installation. A4 impacts are influenced by transportation distances between the manufacturing facility and installation sites. The longer the shipping distance, the greater the contribution to total impacts. A5 impacts stem mainly from the use of ancillary materials, including sealants and fasteners, and from diesel consumption associated with crane operations for lifting and positioning panels at the installation sites.

End-of-life modules, particularly C2, which represents the transportation of waste to disposal facilities, and C4, which represents disposal and landfilling, also contribute noticeably to the overall life cycle results. These impacts are more significant in categories such as smog formation, which results from emissions during waste transport, and non-carcinogenic and ecotoxicity impacts, which result from landfilling processes.

Table 29. Life cycle impact assessment results for X-Series MCM system per declared unit

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	kg CFC-11 eq	3.59E-05	3.65E-06	1.01E-05	6.56E-06	3.48E-06	MND	0	1.26E-06	0	4.81E-07	**6.14E-05**
Global warming	kg CO2 eq	2.63E+03	2.66E+02	5.64E+02	4.78E+02	2.37E+02	MND	0	7.85E+01	0	1.72E+01	**4.27E+03**
Smog	kg O3 eq	1.11E+02	5.30E+00	2.76E+01	9.51E+00	1.71E+01	MND	0	1.17E+01	0	3.20E+00	**1.85E+02**
Acidification	kg SO2 eq	9.92E+00	3.70E-01	1.77E+00	6.63E-01	8.38E-01	MND	0	3.80E-01	0	1.73E-01	**1.41E+01**
Carcinogenics	CTUh	1.29E-03	6.87E-06	2.38E-05	1.23E-05	5.89E-05	MND	0	1.37E-07	0	4.29E-06	**1.39E-03**
Non carcinogenics	CTUh	5.72E-04	4.29E-05	5.36E-04	7.70E-05	5.37E-05	MND	0	3.73E-06	0	2.22E-04	**1.51E-03**
Respiratory effects	kg PM2.5 eq	1.48E+00	8.21E-02	2.57E-01	1.47E-01	1.56E-01	MND	0	4.78E-02	0	2.04E-02	**2.19E+00**
Ecotoxicity	CTUe	3.16E+04	9.77E+02	3.20E+04	1.75E+03	3.06E+03	MND	0	1.94E+01	0	7.54E+03	**7.69E+04**
Freshwater eutrophication	kg P eq	2.21E-01	1.11E-02	2.96E-01	2.00E-02	5.81E-02	MND	0	2.78E-04	0	1.37E-02	**6.20E-01**
Marine eutrophication	kg N eq	1.13E+00	4.61E-02	3.21E-01	8.27E-02	1.28E-01	MND	0	9.83E-02	0	2.70E-02	**1.83E+00**

Overall, A1 and A3 are the most impactful modules of the product life cycle. Their dominance is driven by two main factors: the upstream production and processing of raw materials and components, and the electricity required for manufacturing operations at the facility. While other life cycle modules contribute to environmental impacts, their influence is relatively minor in comparison.

Table 30. Percent contributions of life cycle modules for X-Series MCM system

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	%	58.18%	5.93%	16.41%	10.63%	5.64%	MND	0	2.05%	0	0.78%	**100%**
Global warming	%	61.41%	6.21%	13.17%	11.15%	5.52%	MND	0	1.84%	0	0.40%	**100%**
Smog	%	59.10%	2.84%	14.74%	5.09%	9.16%	MND	0	6.35%	0	1.73%	**100%**
Acidification	%	69.89%	2.60%	12.50%	4.67%	5.90%	MND	0	2.69%	0	1.22%	**100%**
Carcinogenics	%	92.32%	0.49%	1.71%	0.89%	4.23%	MND	0	0.01%	0	0.31%	**100%**
Non carcinogenics	%	37.15%	2.79%	34.85%	5.00%	3.49%	MND	0	0.25%	0	14.76%	**100%**
Respiratory effects	%	67.23%	3.74%	11.69%	6.71%	7.10%	MND	0	2.18%	0	0.93%	**100%**
Ecotoxicity	%	40.48%	1.25%	41.06%	2.25%	3.93%	MND	0	0.03%	0	9.80%	**100%**
Freshwater eutrophication	%	35.57%	1.79%	47.52%	3.21%	9.35%	MND	0	0.04%	0	2.21%	**100%**
Marine eutrophication	%	61.05%	2.49%	17.34%	4.48%	6.93%	MND	0	5.37%	0	1.47%	**100%**

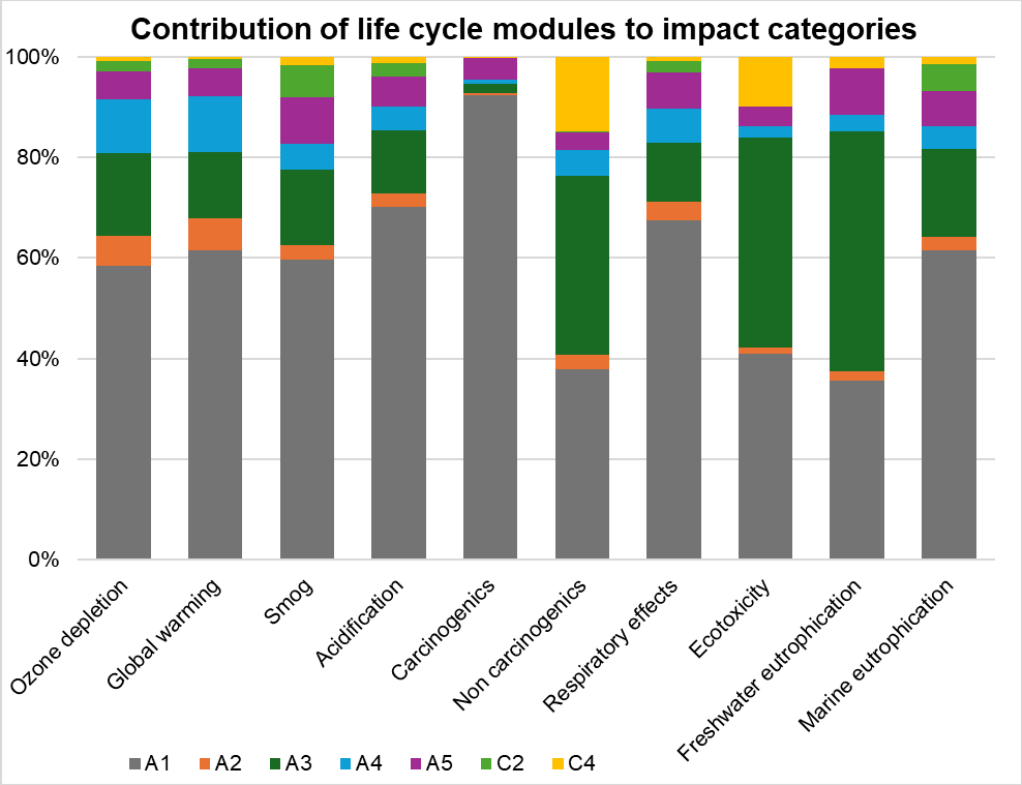


Figure 11. Contribution analysis of impact categories for X-Series MCM system

The SM2013 Methodology single figure millipoint (mPt) score by life cycle module for this product is presented in Table 31. The raw material extraction and upstream production module (A1) dominates the results (~80%), followed by the manufacturing module (~10%).

Table 31. SM millipoint scores for X-Series MCM system per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
SM single figure score	mPts	2.80E+03	3.18E+01	3.59E+02	5.70E+01	1.50E+02	MND	0	3.66E+00	0	8.03E+01	**3.49E+03**

A detailed evaluation of global warming potential (GWP) was conducted to understand the product's potential kg CO2 equivalent emissions. As discussed earlier, module A1 is the largest contributor to total GWP (~61%), followed by module A3 (~13%). Modules A4 and A5 also account for a notable share of emissions, while the remaining life cycle stages contribute relatively little, as illustrated in Figure 12. A more granular analysis of module A1 was performed to determine the GWP contribution of individual material layers. This analysis shows that more than half of the GWP from A1 is attributed to the cold-formed steel framing layer (~46%). Z girt adds up another ~19% of the GWP to A1 and all other layers together make up the remaining share, with no single layer approaching the impact level of the framing.

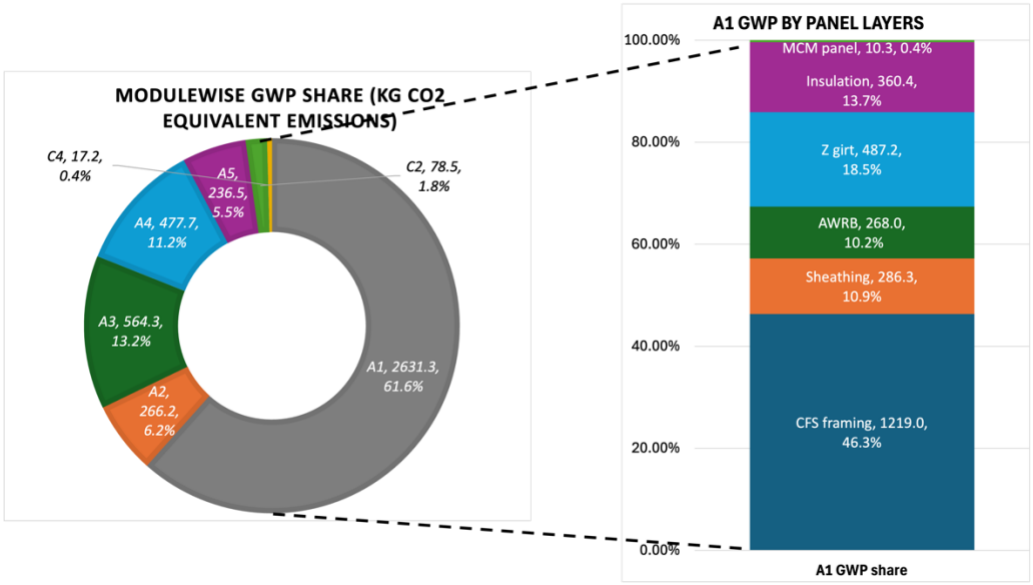


Figure 12. Module wise evaluation of GWP and breakdown by panel layers

5.3.4 X-Series MCM (with openings)

The LCIA results for the X-Series MCM system (with openings) per declared unit are shown in Table 32. The percent contribution of each associated life cycle module is tabulated in Table 33 and is also presented in Figure 13.

The product's life cycle impacts are primarily driven by the cradle-to-gate modules A1, A2, and A3, which together account for the majority of the environmental burdens. Among these modules, A1, which includes the extraction of raw materials, and the upstream production of wall system components delivered to the DBC facility, dominates most impact categories. For freshwater eutrophication, however, A3 is the leading contributor. A3 encompasses all manufacturing operations at the DBC facility, with impacts primarily influenced by electricity use, landfilling of manufacturing waste, and sourcing of packaging materials for final product packaging. Electricity consumption and packaging materials are the main contributors to A3's global warming potential (GWP), while waste landfilling is a key driver of eutrophication and ecotoxicity impacts.

Following A1 and A3, the next most significant contributors are A4, which represents product distribution, and A5, which represents installation. A4 impacts are influenced by transportation distances between the manufacturing facility and installation sites. The longer the shipping distance, the greater the contribution to total impacts. A5 impacts stem mainly from the use of ancillary materials, including sealants and fasteners, and from diesel consumption associated with crane operations for lifting and positioning panels at the installation sites.

Table 32. Life cycle impact assessment results for X-Series MCM system (with openings) per declared unit

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	kg CFC-11 eq	3.17E-05	3.32E-06	1.11E-05	6.12E-06	3.89E-06	MND	0	1.16E-06	0	4.45E-07	**5.78E-05**
Global warming	kg CO2 eq	2.58E+03	2.42E+02	6.20E+02	4.46E+02	2.63E+02	MND	0	7.26E+01	0	1.61E+01	**4.24E+03**
Smog	kg O3 eq	1.07E+02	4.82E+00	2.89E+01	8.88E+00	1.83E+01	MND	0	1.09E+01	0	2.96E+00	**1.82E+02**
Acidification	kg SO2 eq	9.44E+00	3.36E-01	1.89E+00	6.19E-01	9.22E-01	MND	0	3.51E-01	0	1.59E-01	**1.37E+01**
Carcinogenics	CTUh	1.49E-03	6.24E-06	2.52E-05	1.15E-05	6.91E-05	MND	0	1.27E-07	0	4.22E-06	**1.61E-03**
Non carcinogenics	CTUh	6.93E-04	3.90E-05	6.20E-04	7.18E-05	6.04E-05	MND	0	3.45E-06	0	2.04E-04	**1.69E-03**
Respiratory effects	kg PM2.5 eq	1.50E+00	7.46E-02	2.65E-01	1.37E-01	1.74E-01	MND	0	4.42E-02	0	1.88E-02	**2.21E+00**
Ecotoxicity	CTUe	3.76E+04	8.88E+02	3.75E+04	1.64E+03	3.37E+03	MND	0	1.80E+01	0	6.92E+03	**8.80E+04**
Freshwater eutrophication	kg P eq	2.25E-01	1.01E-02	3.43E-01	1.86E-02	6.19E-02	MND	0	2.57E-04	0	1.63E-02	**6.75E-01**
Marine eutrophication	kg N eq	1.07E+00	4.19E-02	3.47E-01	7.72E-02	1.35E-01	MND	0	9.10E-02	0	2.54E-02	**1.78E+00**

End-of-life modules, particularly C2, which represents the transportation of waste to disposal facilities, and C4, which represents disposal and landfilling, also contribute noticeably to the overall life cycle results. These impacts are more significant in categories such as smog formation, which results from emissions during waste transport, and non-carcinogenic and ecotoxicity impacts, which result from landfilling processes.

Overall, A1 and A3 are the most impactful modules of the product life cycle. Their dominance is driven by two main factors: the upstream production and processing of raw materials and components, and the electricity required for manufacturing operations at the facility. While other life cycle modules contribute to environmental impacts, their influence is relatively minor in comparison.

Table 33. Percent contributions of life cycle modules for X-Series MCM system (with openings)

Impact category	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
Ozone depletion	%	54.68%	5.73%	19.18%	10.55%	6.70%	MND	0	2.02%	0	0.77%	**100%**
Global warming	%	60.69%	5.69%	14.58%	10.48%	6.18%	MND	0	1.71%	0	0.38%	**100%**
Smog	%	58.33%	2.62%	15.72%	4.83%	9.94%	MND	0	5.97%	0	1.63%	**100%**
Acidification	%	68.46%	2.44%	13.71%	4.49%	6.69%	MND	0	2.56%	0	1.16%	**100%**
Carcinogenics	%	92.72%	0.39%	1.57%	0.72%	4.30%	MND	0	0.01%	0	0.26%	**100%**
Non carcinogenics	%	40.28%	2.27%	36.07%	4.18%	3.51%	MND	0	0.20%	0	12.04%	**100%**
Respiratory effects	%	67.51%	3.36%	11.90%	6.18%	7.82%	MND	0	2.00%	0	0.85%	**100%**
Ecotoxicity	%	42.33%	1.00%	42.16%	1.84%	3.79%	MND	0	0.02%	0	7.87%	**100%**
Freshwater eutrophication	%	33.22%	1.49%	50.61%	2.75%	9.14%	MND	0	0.04%	0	2.41%	**100%**
Marine eutrophication	%	59.25%	2.33%	19.29%	4.29%	7.48%	MND	0	5.10%	0	1.42%	**100%**

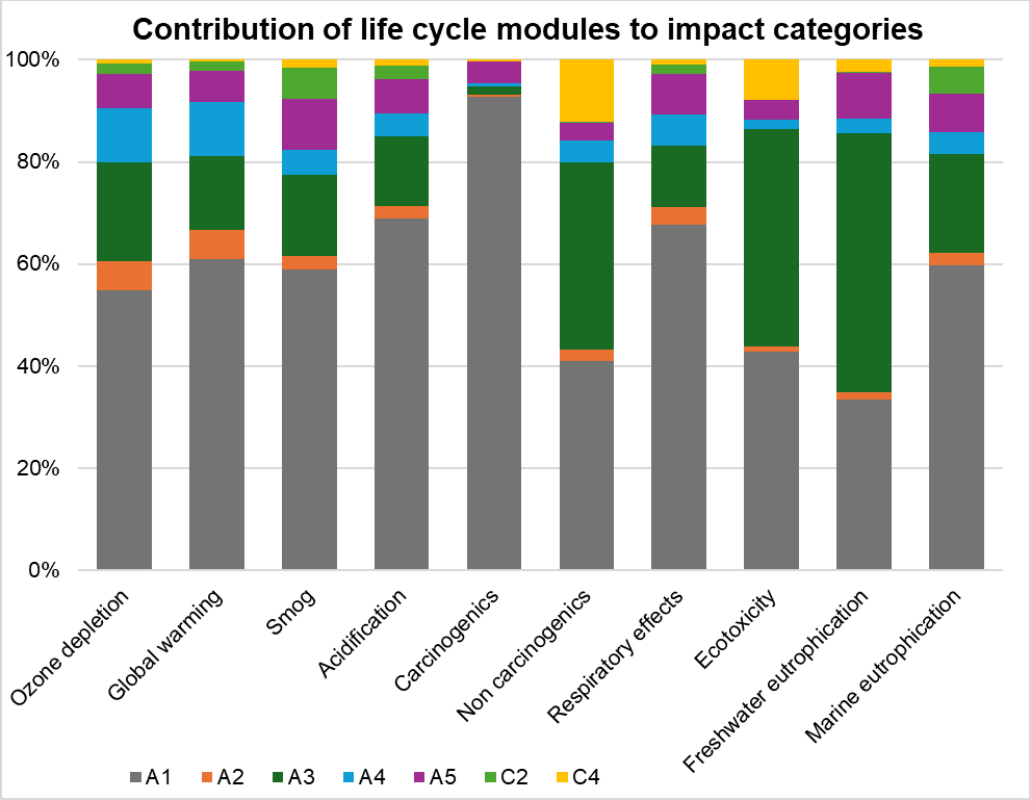


Figure 13. Contribution analysis of impact categories for X-Series MCM system (with openings)

The SM2013 Methodology single figure millipoint (mPt) score by life cycle module for this product is presented in Table 34. The raw material extraction and upstream production module (A1) dominates the results (~81%), followed by the manufacturing module (~10%).

Table 34. SM millipoint scores for X-Series MCM system (with openings) per declared unit

Parameter	Unit	Production			Construction/ Installation		Use	End of life				Total
		A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	
SM single figure score	mPts	3.24E+03	2.89E+01	4.13E+02	5.32E+01	1.73E+02	MND	0	3.38E+00	0	7.45E+01	**3.99E+03**

A detailed evaluation of global warming potential (GWP) was conducted to understand the product's potential kg CO2 equivalent emissions. As discussed earlier, module A1 is the largest contributor to total GWP (~61%), followed by module A3 (~15%). Modules A4 and A5 also account for a notable share of emissions, while the remaining life cycle stages contribute relatively little, as illustrated in Figure 14. A more granular analysis of module A1 was performed to determine the GWP contribution of individual material layers. This analysis shows that more than half of the GWP from A1 is attributed to the cold-formed steel framing layer (~48%). Z girt adds up another ~16% of the GWP to A1 and all other layers together make up the remaining share, with no single layer approaching the impact level of the framing. Windows and openings make up ~4% of the A1 GWP, which was absent in the solid panels.

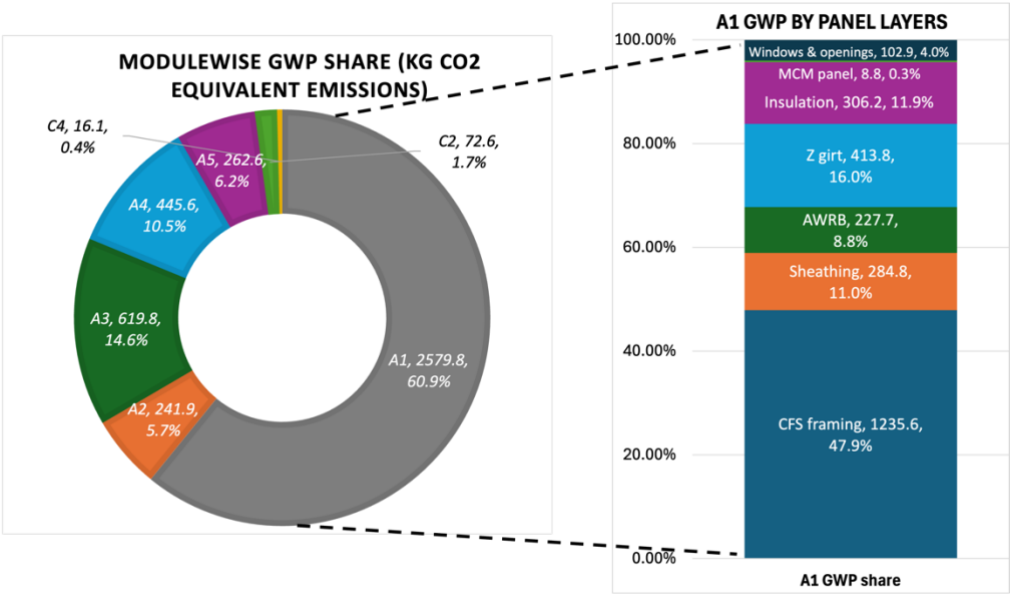


Figure 14. Module wise evaluation of GWP and breakdown by panel layers

5.4 Analysis of impact drivers

For each impact category of interest to DBC, detailed analyses were performed to identify major unit processes that contributed significantly to the overall product life cycle impacts of panelized exterior wall systems. Table 35 lists each major driver with >10% contribution to the overall life cycle impacts.

Table 35. Major drivers of panelized exterior wall systems life cycle impacts

Impact category	Major flow (with impacts contributing >10%)	Actual contribution	
		X-Series EIFS	X-Series MCM
Global warming	A1- Cold rolled steel coil	34.0%	27.4%
	A1- Z girt materials & upstream production	NA	11.4%
	A4- Shipment to building sites	<10%	11.2%
Ozone depletion	A1- Reinforcing mesh materials & upstream production	35.3%	NA
	A1- Sheathing fabric materials &upstream production	26.2%	NA
	A1- Glass sheathing materials &upstream production	<10%	23.5%
	A1- Mineral wool insulation materials & upstream production	NA	15.8%
Ecotoxicity	A1- U channel	11.6%	<10%
	A1- Z girt materials & upstream production	NA	14.3%
	A1- Flashing angles	NA	13.3%
	A3- Landfilling of manufacturing waste	38.5%	39.7%
	C4- Inert waste disposal	13.5%	<10%

Table 36 lists information about all the data sets contributing 10% or more to any environmental impact category.

Table 36. Data sets contributing 10% or more to any impact category

Data set name	Database	Software type and version	Reference year	Geography	Data set allocation
Steel cold rolled coil {GLO} | blast furnace route and electric arc furnace route | production mix, at plant | 1kg, typical thickness between 0.15 - 3 mm. typical width between 600 - 2100 mm | LCI result	Industry data 2.0	SimaPro Craft 10.2	2021	Global	System expansion
Transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 {RoW}| market for transport, freight, lorry, 16-32 metric ton, diesel, EURO 6 | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2014	Rest of World	Cut-off
Glass wool mat {RoW}| glass wool mat production | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2024	Rest of World	Cut-off
Fibre, polyester {GLO}| market for fibre, polyester | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2018	Rest of World	Cut-off
Gypsum plasterboard {RoW}| gypsum plasterboard production | Cut-off, U (manually updated to match upstream EPD)	ecoinvent v3.11	SimaPro Craft 10.2	2019	Rest of World	Cut-off
Stone wool {RoW}| stone wool production | Cut-off, U (manually updated to match upstream EPD)	ecoinvent v3.11	SimaPro Craft 10.2	2024	Rest of World	Cut-off
Steel, low-alloyed {GLO}| market for steel, low-alloyed | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2020	Rest of World	Cut-off
Municipal solid waste {RoW}| treatment of municipal solid waste, sanitary landfill | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2023	Rest of World	Cut-off
Inert waste {RoW}| treatment of inert waste, sanitary landfill | Cut-off, U	ecoinvent v3.11	SimaPro Craft 10.2	2014	Rest of World	Cut-off

5.5 Uncertainty analysis

There is inherent uncertainty in both foreground and background data used in life cycle assessment. In this study, primary data for the foreground system were sourced from DBC and other reliable references to minimize uncertainty, while the most representative proxies were selected during LCA modeling. Uncertainties associated with background processes, as well as variations in data set choices and impact assessment methods, were addressed separately through a Monte Carlo simulation. This method propagates uncertainty by predicting the probability of a variety of outcomes through repeated random sampling. The uncertainty analysis was conducted for both EIFS and MCM systems, using 1,000 iterations to generate 95% confidence intervals. This approach allows for a quantitative evaluation of the potential variability in results arising from data selection and methodological assumptions.

Figure 15 represents the uncertainty associated with the background data sets in the X-Series EIFS system, which indicates that several impact categories show notable variations. The mean values for global warming, acidification, smog, and marine eutrophication may vary roughly 6–10% lower to 7–11% higher, indicating relatively low uncertainty and demonstrating that these impact categories are stable. In contrast, ecotoxicity, carcinogenic, and non-carcinogenic impacts exhibit considerably higher variability, with coefficients of variation exceeding 30%, reflecting either poorly characterized toxicity data or significant uncertainty in background data set inventories. Non-carcinogenic impacts in particular show extreme instability.

Figure 16 shows the uncertainty associated with the background data sets in the X-Series MCM system. Global warming, acidification, smog, and marine eutrophication are relatively stable, while non-carcinogenic impacts display extreme uncertainty, mirroring the pattern seen in the X-Series EIFS.

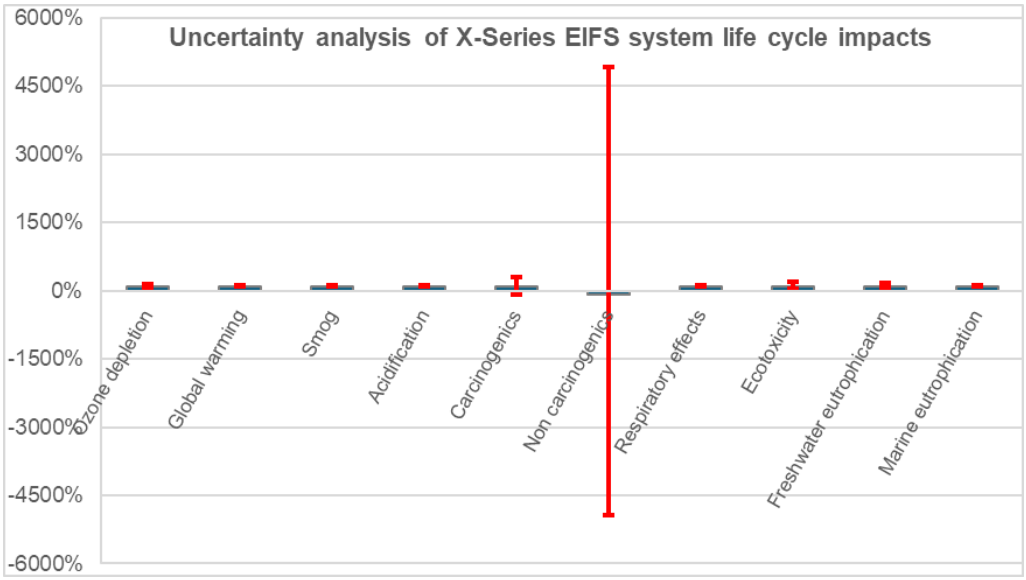


Figure 15. Uncertainty analysis of X-Series EIFS system life cycle impacts per declared unit

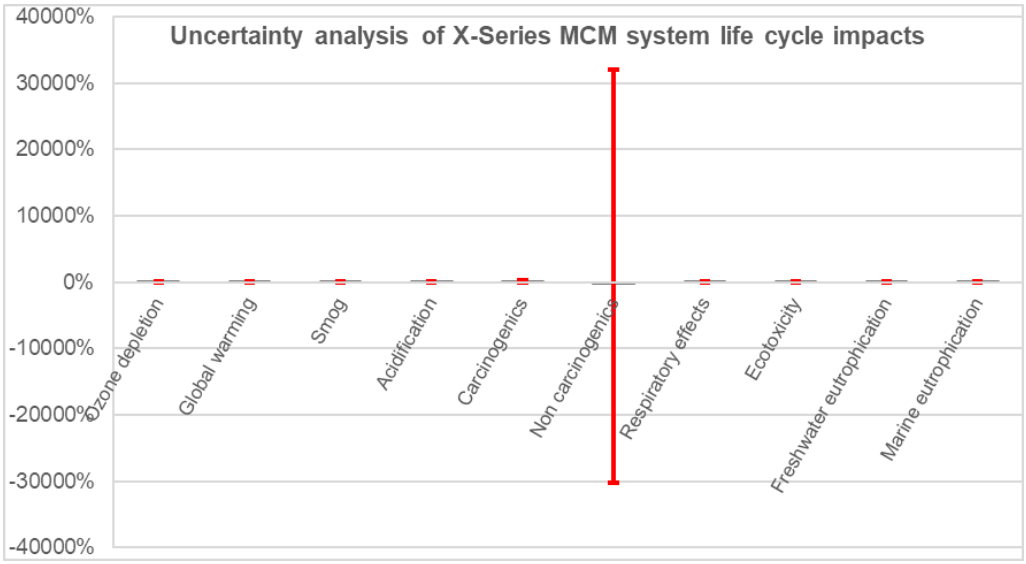


Figure 16. Uncertainty analysis of X-Series MCM system life cycle impacts per declared unit

5.6 Sensitivity analysis

It is critical to understand the relative importance of different inputs in an LCA. Sensitivity analysis is essential to understand how variations in key inputs affect the results. It identifies which assumptions and data points significantly influence environmental impacts, assesses uncertainties, and improves model reliability.

The life cycle impact assessment results for each system type indicate that module A1 is the largest contributor to overall impacts, followed by module A3. A1 impacts are primarily associated with the extraction of raw materials, upstream processing, and component production, which are activities that occur outside of DBC's direct control. Given that A3 reflects manufacturing activities within DBC's operations, the sensitivity analysis focuses on parameters within this module to understand how variations could affect overall life cycle results. With input from DBC, two parameters were identified for testing: (1) the share of solar energy in the manufacturing facility's energy mix, and (2) the waste management practices applied to manufacturing waste. Evaluating these parameters through sensitivity analysis helps illustrate how changes in operational decisions or assumptions could shift the environmental profile of the product.

Results were generated and presented for all impact categories, with each parameter affecting the categories to varying degrees. For example, electricity consumption is the primary contributor to A3 GWP and ozone depletion but has a relatively minor influence on ecotoxicity. In contrast, the current practice of landfilling manufacturing waste has a greater impact on categories such as ecotoxicity and eutrophication, while its contribution to A3 GWP and ozone depletion is limited.

5.6.1 Changing share of solar energy

DBC already uses on-site solar power that supplies a portion of the facility's electricity, reducing reliance on the power grid. To evaluate how variations in solar use affect environmental performance, two scenarios were developed: one in which the facility's electricity is sourced entirely from solar power (100% on-site solar), and another in which it is sourced entirely from the grid (0% on-site solar). These scenarios were compared against the base case.

As shown in Table 37, changing the share of solar power has a notable effect on impacts within module A3 but results in relatively small changes to the overall life cycle. The variation is most evident in global warming potential (GWP) and ozone depletion, as electricity consumption is the dominant contributor to those impact categories. In contrast, categories such as ecotoxicity and eutrophication are less sensitive to changes in electricity sourcing, as they are more strongly influenced by other factors such as waste management practices.

Table 37. Sensitivity analysis of changing share of solar in A3 electricity consumption

Sensitivity analysis scenario	X-Series EIFS				X-Series MCM			
	A3 value	% change	Total value	% change	A3 value	% change	Total value	% change
Global warming (kg CO_2 eq)								
Current solar share (32-54%)	4.86E+02	-	3.03E+03	-	5.64E+02	-	4.27E+03	-
0% on-site solar	6.96E+02	+43.3%	3.24E+03	+6.93%	6.54E+02	+15.8%	4.36E+03	+2.09%
100% on-stie solar	3.11E+02	-36.0%	2.86E+03	-5.76%	3.75E+02	-33.5%	4.08E+03	-4.43%
Ozone depletion (kg CFC-11 eq)								
Current solar share (32-54%)	9.58E-06	-	1.03E-04	-	1.01E-05	-	6.14E-05	-
0% on-site solar	1.56E-05	+62.7%	1.09E-04	+5.82%	1.27E-05	+25.2%	6.40E-05	+4.15%
100% on-stie solar	4.59E-06	-52.1%	9.81E-05	-4.84%	4.71E-06	-53.4%	5.60E-05	-8.80%
Smog (kg O3)								
Current solar share (32-54%)	2.61E+01	-	1.36E+02	-	2.76E+01	-	1.85E+02	-
0% on-site solar	3.19E+01	22.11%	1.42E+02	4.25%	3.00E+01	8.89%	1.87E+02	1.33%
100% on-stie solar	2.13E+01	-18.39%	1.31E+02	-3.53%	2.24E+01	-18.84%	1.80E+02	-2.81%
Acidification (kg SO2)								
Current solar share (32-54%)	1.69E+00	-	9.74E+00	-	1.77E+00	-	1.41E+01	-
0% on-site solar	2.32E+00	37.24%	1.04E+01	6.45%	2.04E+00	15.05%	1.44E+01	1.89%
100% on-stie solar	1.16E+00	-30.96%	9.22E+00	-5.36%	1.21E+00	-31.88%	1.36E+01	-4.01%
Carcinogenics (CTUh)								
Current solar share (32-54%)	2.15E-05	-	4.41E-04	-	2.38E-05	-	1.39E-03	-
0% on-site solar	2.59E-05	20.76%	4.45E-04	1.01%	2.57E-05	7.96%	1.39E-03	0.14%
100% on-stie solar	1.78E-05	-17.26%	4.37E-04	-0.84%	1.98E-05	-16.86%	1.39E-03	-0.29%
Non carcinogenics (CTUh)								
Current solar share (32-54%)	2.98E-04	-	8.65E-04	-	5.36E-04	-	1.51E-03	-
0% on-site solar	3.16E-04	6.02%	8.83E-04	2.08%	5.44E-04	1.42%	1.52E-03	0.51%
100% on-stie solar	2.84E-04	-5.01%	8.50E-04	-1.73%	5.20E-04	-3.02%	1.49E-03	-1.07%
Respiratory effects (kg PM 2.5 eq)								
Current solar share (32-54%)	2.49E-01	-	1.46E+00	-	2.57E-01	-	2.19E+00	-
0% on-site solar	2.85E-01	14.77%	1.50E+00	2.51%	2.72E-01	6.08%	2.20E+00	0.71%
100% on-stie solar	2.18E-01	-12.28%	1.43E+00	-2.09%	2.24E-01	-12.88%	2.15E+00	-1.51%
Ecotoxicity (CTUe)								
Current solar share (32-54%)	1.63E+04	-	3.84E+04	-	3.20E+04	-	7.69E+04	-
0% on-site solar	1.66E+04	+2.42%	3.88E+04	+1.02%	3.22E+04	+0.52%	7.71E+04	+0.22%
100% on-stie solar	1.59E+04	-2.01%	3.80E+04	-0.85%	3.17E+04	-1.11%	7.76E+04	-0.46%
Freshwater eutrophication (kg P eq)								
Current solar share (32-54%)	1.65E-01	-	4.21E-01	-	2.96E-01	-	6.20E-01	-
0% on-site solar	1.82E-01	10.54%	4.38E-01	4.13%	3.03E-01	2.50%	6.27E-01	1.19%
100% on-stie solar	1.50E-01	-8.76%	4.06E-01	-3.43%	2.80E-01	-5.29%	6.04E-01	-2.52%
Marine eutrophication (kg N eq)								
Current solar share (32-54%)	2.65E-01	-	1.22E+00	-	3.21E-01	-	1.83E+00	-
0% on-site solar	3.17E-01	19.57%	1.27E+00	4.26%	3.43E-01	6.88%	1.85E+00	1.20%
100% on-stie solar	2.22E-01	-16.28%	1.17E+00	-3.54%	2.74E-01	-14.57%	1.78E+00	-2.55%

5.6.2 Changing waste management practices

Due to the lack of detailed waste characterization data, this study assumes that all manufacturing waste generated at the DBC facility is disposed of through landfilling. However, DBC is actively working to expand recycling initiatives as part of its waste management practices. To explore how changes in waste management could affect environmental performance, three scenarios were developed: one where 50% of the waste stream is recycled, one where 75% is recycled, and one where 100% is recycled. While full recycling is not feasible since not all materials are recyclable or reusable, these scenarios provide a useful comparison against the base case of 100% landfilling.

Altering waste management practices has a significant influence on impacts within module A3 and also affects overall life cycle results. The variation is most pronounced in ecotoxicity and freshwater eutrophication, where landfilling is a major contributor to A3 impacts. A 19-40% reduction in total ecotoxicity and 14-41% reduction in freshwater eutrophication was seen across the three recycling scenarios.

In contrast, categories such as global warming potential (GWP) and ozone depletion are less sensitive to waste management changes because they are more heavily influenced by other parameters, such as electricity consumption. A 5-20% reduction in total GWP and 0.02-0.11% reduction in ozone depletion was seen across the three recycling scenarios.

5.7 Overview of relevant findings

This study evaluated a wide range of inventory data and environmental impact indicators. For both panelized exterior wall systems evaluated in this study, the results show that the cradle-to-gate modules were the dominant contributors across all impact categories. Within these modules, raw material extraction and upstream processing accounted for the largest share of impacts, followed by impacts from manufacturing processes.

Within the raw material extraction and upstream processing module, most environmental impacts stemmed from the upstream manufacturing of product system components, with steel framing contributing the largest share of global warming potential results. The production of steel and other components is highly energy-intensive, making this module a major driver of the overall environmental footprint. Once these upstream components are manufactured, they are transported to the DBC facility for further processing and assembly into the final wall systems.

Transportation of materials to the facility also contributed to several environmental impact categories. Its contribution is more pronounced for the X-Series MCM system than for the X-Series EIFS system because several of the MCM system components were sourced from greater distances.

Impacts from manufacturing operations at the DBC facility were primarily influenced by electricity consumption. Across most environmental categories, the facility's energy use significantly affected the impacts in this module, underscoring the importance of energy management strategies. In addition, waste management practices played a key role, as the handling and disposal of manufacturing waste contributed substantially to ecotoxicity and eutrophication.

Although other life cycle modules also contributed to the overall environmental profile, their influence was relatively minor compared to the cradle-to-gate modules. The absence of product scrap during on-site installation and the practice of returning product packaging to the DBC facility for reuse has further helped to minimize installation-related impacts.

5.8 Conclusion and recommendations

The goal of this study was to conduct an LCA on DBCs' X-Series panelized exterior wall systems so as to develop a Transparency Report [EPD]™. The creation of this TR will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with products they choose. Overall, this analysis highlights that the raw material extraction and upstream processing is the most significant contributor to the products' overall environmental impacts, followed by product manufacturing.

As DBC has direct control over its own manufacturing operations, there are opportunities to reduce the environmental impacts associated with this module. One important area of focus is electricity consumption during production processes, which directly influences the facility's overall environmental footprint. Expanding the use of renewable energy within the facility, whether through additional on-site solar panels, wind turbines, or other renewable sources, can further reduce reliance on grid electricity and lower associated impacts. Even incremental increases in renewable energy can contribute meaningfully to reducing energy-related environmental burdens and demonstrate proactive sustainability leadership.

Waste management practices at the facility also offer opportunities for environmental improvement. While the current practice of 100% landfilling has minimal effect on global warming potential, it contributes significantly to other impact categories. Recycling or reusing manufacturing scrap can help mitigate these impacts, and if possible, diverting scrap back into production is an effective approach for reducing global warming potential, as it decreases the need for virgin materials. Additionally, process improvements that limit scrap generation can result in substantial reductions across multiple environmental indicators. Together, thoughtful energy management and strategic waste diversion can provide practical pathways for DBC to strengthen its sustainability performance while enhancing the overall robustness of its LCA.

Although raw material extraction and upstream processing are largely outside of DBC's direct control, the company can influence its supply chain by prioritizing suppliers that implement sustainable manufacturing practices. This includes using recycled content in their products, which reduces the need for virgin materials, adopting energy-efficient production methods, and integrating renewable energy into operations. DBC can further support this effort by reviewing EPDs to evaluate the environmental performance of components before selecting suppliers. In addition, environmental impacts can be reduced by choosing suppliers closer to the facility or by working with logistics providers that employ low-emission or hybrid vehicles, thereby minimizing transportation-related impacts.

It is recommended that DBC engage directly with suppliers to obtain detailed data on the production of components that contribute significantly to the overall life cycle impacts, such as steel frames, Z-girts, insulation, and sheathing. Access to supplier-specific data can provide valuable insights into environmental hotspots within upstream production, helping suppliers identify opportunities for improvement. At the same time, this information would allow DBC to refine its

sustainability strategies, enhance the accuracy and robustness of this LCA, and ultimately reduce the overall environmental footprint of its products.

Additionally, an update to this LCA and the associated Transparency Report [EPD]™ would enable high-quality year-to-year comparisons and serve as the basis for a potential optimized EPD. A post-project review could provide opportunities for improving the data collection process in future years and for continuing to align with DBC's goals for sustainability.

6 REFERENCES

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ACRONYMS

ACLCA	American Center for Life Cycle Assessment
BOM	Bill of materials
EIFS	Exterior insulation and finish system
ISO	International Standardization Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle impact analysis
MCM	Metal composite material
PCR	Product Category Rule document
REC	Renewable energy certificates
RSL	Reference service life
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
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]