Environmental Product Declarations

landscapeforms

Orientation Guide

At Landscape Forms, we strive to both make our products responsibly and provide our customers the transparency they need to make the most informed decisions about what goes into their projects. That means looking closely at the resources we use, and understanding impacts at every life cycle stage, even after a product leaves our factory doors. That's why we've developed EPDs, to measure what's hard to measure, for every major material we source.

Why Environmental Product Declarations?

EPDs (short for Environmental Product Declarations) are the gold-standard of environmental data. Learn more from the [Navigating Environmental Product Data] guide by ASLA.

Often referred to as "Nutrition Labels" for products, EPDs use the science of life cycle assessment to disclose real data across impact categories, including potential contribution to global warming, effects on marine and terrestrial ecosystems, and overall utilization of natural resources. EPDs work in concert with our Product Carbon Footprints, providing a more holistic view of each major material we work with.

EPD reports are standardized documents that are third-party verified and informed by layers of best practices. Our EPDs align with the International Organization for Standardization (ISO), an independent, non-governmental organization that brings global experts together to agree on the best way of doing things.

EPDs provide the insights, data, and baselines needed to enable policies and drive better practices across industries. Every new EPD provides more baseline data that is vital to understand and reduce the carbon impacts of construction and the broader environmental impacts of resource extraction.

What You'll Find in Our EPDs

Landscape Forms' EPDs are reported in accordance with ISO 14025, and available on the product pages of our website for download. Additional information can be found in the Life Cycle Assessment background report attached. Through these documents, you'll find details of the investigated systems, the study parameters, data sources and quality assessment, impact assessment methodology, and the critical review.

Landscape Forms' EPDs are inclusive of the entire product life cycle, from Cradle to Grave. If you are utilizing our EPDs as an input to a Whole Project or Whole Building Life Cycle Assessment, we can share totals for Global Warming Potential, broken out in the A1-A3 Cradle to Gate product stages. Reach out to your Business Development Representative for any further needs.

EPDs can enable comparisons between products if:

- The two products are functionally equivalent for identical units
- The EPDs adhere to the same Product Category Rules
- The EPDs report the same life-cycle modules
- The Life Cycle Assessment references the same background data

For More Information

Didn't find what you were looking for? Contact your Landscape Forms Business Development Representative to request additional information and documentation.

Life Cycle Assessment of Outdoor Furniture

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landscapeforms®

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1. General Objective and Description of the Investigated Systems

This report presents the findings of a Life Cycle Assessment (LCA) conducted by SCS Global Services (SCS) of four outdoor furniture products manufactured by Landscape Forms and one outdoor furniture product manufactured by Loll Designs in North America. Landscape Forms chairs are constructed from a variety of materials including wood, steel, plastics, concrete, and aluminum parts. The Landscape Forms products assessed include three (3) chairs and two (2) benches for use in an outdoor setting.

The goals of the study include two primary objectives:

1. To assess the potential environmental impacts, using category indicators specified by the PCR, for the Landscape Forms products over their entire life cycle – raw material extraction and processing, component manufacturing and assembly, and product use, maintenance, and disposal.
2. To serve as the basis of preparing an Environmental Product Declaration (EPD) for the Landscape Forms seating products conformant to the EPD Norge® System Product Category Rule (PCR)[1] for Furniture, EN 15804[2], ISO 14025[3] and ISO 14044[4].

Life Cycle Impact Assessment is calculated using the characterization methodologies specified by the PCR. Impact categories include: Global Warming Potential, Acidification Potential, Photochemical Ozone Creation Potential, Ozone Depletion Potential, Eutrophication Potential, Abiotic Depletion Potential, Toxicity Potential and Land Use/Land Occupation. It should be noted that the PCR does not require reporting of all environmentally relevant impacts, such as impacts to ecosystems, key species habitats, or water resources.

This report is provided to aid in understanding the life cycle impacts for select models of the Landscape Forms seating product for the category indicators specified by the PCR. The intended audience for this technical LCA report includes Landscape Forms, the EPD verifier, and other LCA practitioners or technical audiences with which Landscape Forms choses to share the report. Results presented are not intended for use in comparative assertions. This report *will be/has been* critically reviewed by an internal LCA practitioner independent of the project for conformance to ISO 14044 and the PCR.

[1] Product Category Rule for Furniture. Product Category Classification: NPCR 026. EPD Norge®. Version 2.0. September 2022.

[2] EN 15804:2012+A2:2019, Sustainability in construction works – Environmental product declarations – Core rules for the product

[3] ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations – Principles and procedures

[4] ISO 14044: 2006/AMD 1:2017/ AMD 2:2020 Environmental Management – Life cycle assessment – Requirements and Guidelines.

2. Study Parameters

2.1 Goal and Scope of the Assessment

The LCA scope of this study is "cradle-to-grave" (Figure 1), including raw material extraction and processing, component manufacturing and assembly, packaging, distribution, product use, maintenance and disposal. Resource consumption, emissions and wastes and their associated potential environmental impacts, are calculated for five (5) Landscape Forms seating products, both upstream and downstream from the Landscape Forms and Loll Designs manufacturing facilities. A general representation of life cycle phases included is shown in Figure 1.

Product			Construction Process		Use							End-of-life				Benefits and loads beyond the system boundary
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material extraction and processing	Transport to manufacturer	Manufacturing	Transport	Construction - installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Benefits and loads beyond the system boundary
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Figure 1. A general representation of the scope of the LCA, including all life cycle stages from cradle-to-grave.

2.2 Functions of the Product System and the Functional Unit

Landscape Forms seating products provide the primary function of seating. Seating includes both chairs and benches, both of which have a primary function of providing a surface for sitting. The products are warrantied for 3 years from the date of invoice but may be expected to perform their primary function longer than the warrantied period without need for repair. Landscape Forms notes that typically customers have kept the products in use between 7-10 years and replace for aesthetic purposes, whereas others have lasted 30 or more years. The reference service life (RSL) used for these products is assumed to be 15 years of use with no maintenance or replacement, per the EPD Norge PCRs.

The declared unit used is one unit of product. The reference flow for each of the products is one unit of product.

Table 1. Reference flows for the Landscape Forms product systems.

		Reference flows (kg)
Product Name	Declared Unit	Product
Chipman Chair	1 product	9.33
Parc Centre Chair	1 product	11.5
FGP Bench	1 product	46.3
AD100 Strata Bench	1 product	216
Adirondack Chair	1 product	18.6

2.3 System Boundary

The product system under study is a cradle-to-grave study, as specified by the PCR and guidance documents, and includes the following life cycle stages (modules):

Table 2. Reference flows for the Landscape Forms product systems.

Module	Module description from the PCR	Unit Processes Included in Scope
A1	Extraction and processing of raw materials; any reuse of products or materials from previous product systems; processing of secondary materials; generation of electricity from primary energy resources; energy, or other, recovery processes from secondary fuels	Extraction and processing of raw materials for the material components.
A2	Transport (to the manufacturer)	Transport of component materials to the manufacturing facility
A3	Manufacturing, including ancillary material production	Manufacturing of flooring products and packaging (incl. upstream unit processes)
A4	Transport (to the building site)	Transport of product (including packaging) to the building site
A5	Construction-installation process	Impacts from the installation of product are assumed negligible. Impacts from the production, transport and disposal of waste material associated with installation are included in this phase in addition to impacts from packaging disposal.
B1	Product use	Use of the flooring in a commercial building setting. There are no associated emissions or impacts from the use of the product
B2	Product maintenance	The furniture is not expected to require maintenance over its lifetime.
B3	Product repair	The furniture is not expected to require repair over its lifetime.
B4	Product replacement	The furniture is not expected to require replacement over its lifetime.
B5	Product refurbishment	The furniture is not expected to require refurbishment over its lifetime.
B6	Operational energy use by technical building systems	There is no operational energy use associated with the use of the product
B7	Operational water use by technical building systems	There is no operational water use associated with the use of the product
C1	Deconstruction, demolition	Demolition of the product is accomplished using hand tools with no associated emissions and negligible impacts
C2	Transport (to waste processing)	Transport of product to waste treatment at end-of-life
C3	Waste processing for reuse, recovery and/or recycling	The product is disposed of by landfilling which require no waste processing
C4	Disposal	Disposal of flooring product in municipal landfill
D	Benefits and loads beyond the system boundary	Reuse, recovery, and recycling of materials.

The product system under study includes the production of all the components shown in Table 7 (Section 2.12), as well as transportation to point of use, installation, use and maintenance, and end-of-life (see Figure 2). The system boundaries include all unit processes contributing measurably to category indicator results for those category indicators specified in the PCR.

All inputs and outputs relevant to the production of the products were included in the LCA calculations. According to EN15804, processes contributing greater than 1% on a mass or energy basis be included in the inventory. In the present study, all known materials and processes were included in the life cycle inventory. In addition, the cut-off rules are not applied to hide data and no revisions or refinements of product system boundaries were implemented due to cut-off criteria, or as a result of sensitivity analyses (Section 4.4).

The specification of the system boundary for the product system aligns with the following two LCA modeling principles:

1. The “modularity principle”: Processes influencing the construction product’s environmental performance during its life cycle are assigned to the information module of the life cycle stage where they occur; all environmental aspects and potential impacts are declared in the life cycle stage where they can be attributed; and
2. The “polluter pays principle”: Processes relevant to waste processing are assigned to the product system that generates the waste until the system boundary between product systems is reached.

Consistent with PCR requirements, processes excluded from the system boundary include the following:

- Construction activities, capital equipment, and infrastructure,
- Maintenance and operation of capital equipment,
- Personnel travel and resource use.

The deletion of these processes is permitted since it is not expected to significantly change the overall conclusions of the study. In the present study, except where noted above, all known materials and processes were included in the life cycle inventory.

2.4 The Product System under Study

The product systems studied in this lifecycle assessment report include the cradle-to-grave impacts of the outdoor furniture products. The product systems were modeled based on information provided by the manufacturer, including materials, suppliers, modes of transport and transportation distances, packaging materials and completed Data Request Forms for the Landscape Forms and Loll Designs facilities. The Landscape Forms products are manufactured primarily at three facilities in Michigan: two in Kalamazoo, Michigan and one in Richland, Michigan. The FGP Bench and AD100 Strata Bench also undergo electrostatic painting at a third party which is included in the scope; however, since this process was performed by a third party and primary data were not available, representative data were used to model this process. Loll Designs manufactures the Adirondack Chair within their Duluth, Minnesota facility.

A flow diagram of the product system, including system boundaries, is provided in Figures 2-6.

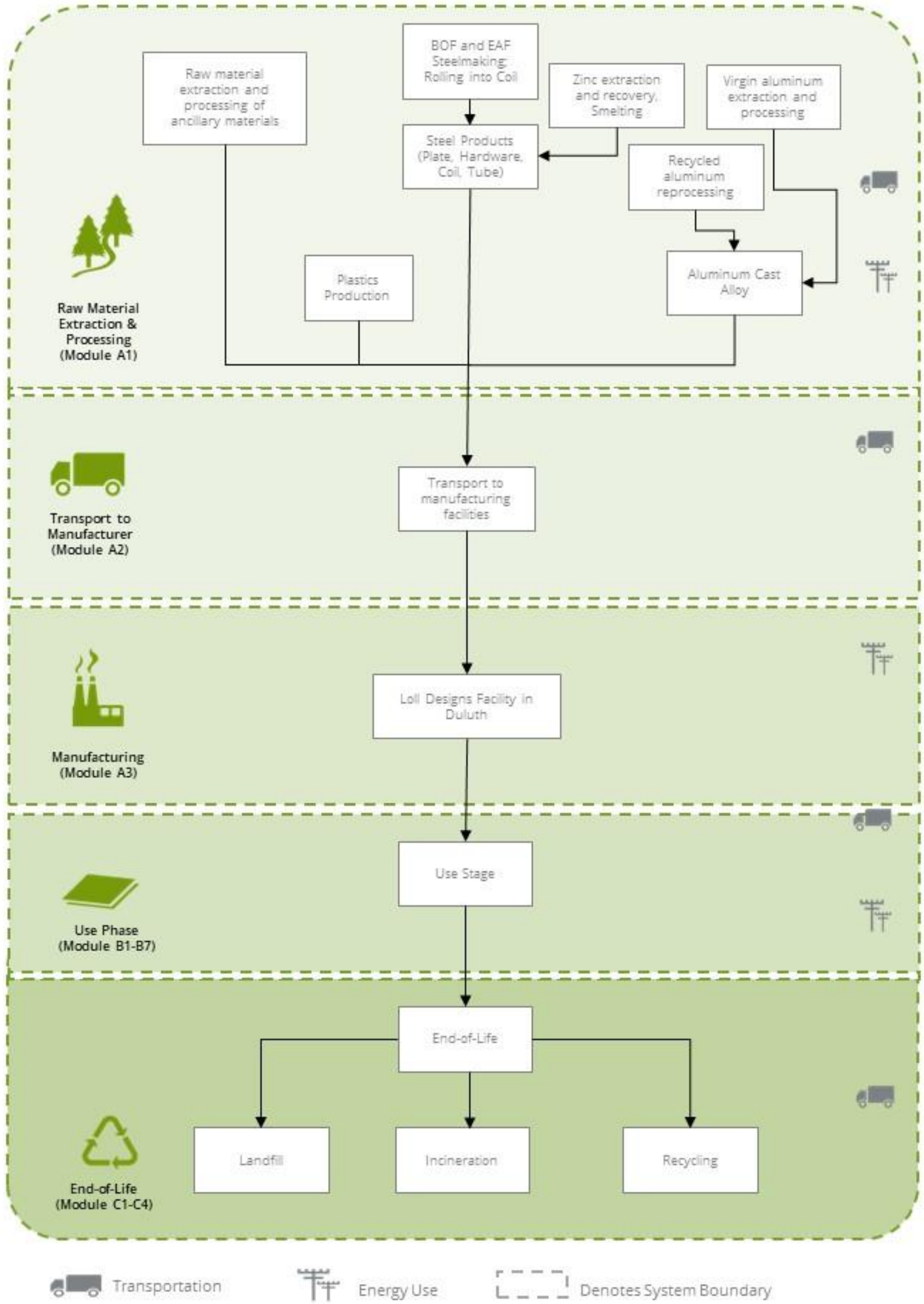

Figure 2. *Process flow diagram to summarize processes and life cycle stages for the ADK Chair.*

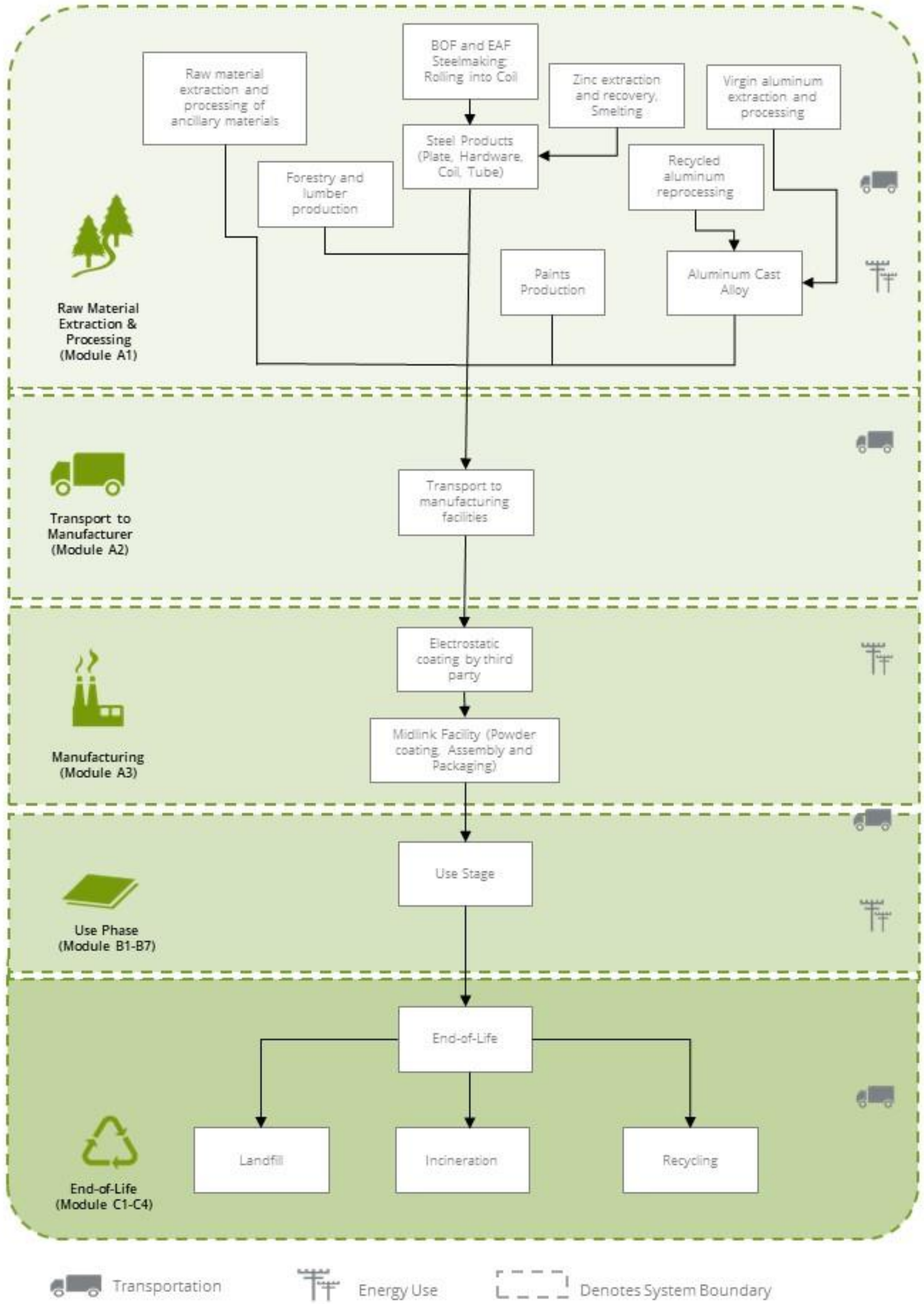

Figure 3. *Process flow diagram to summarize processes and life cycle stages for the FGP Bench.*

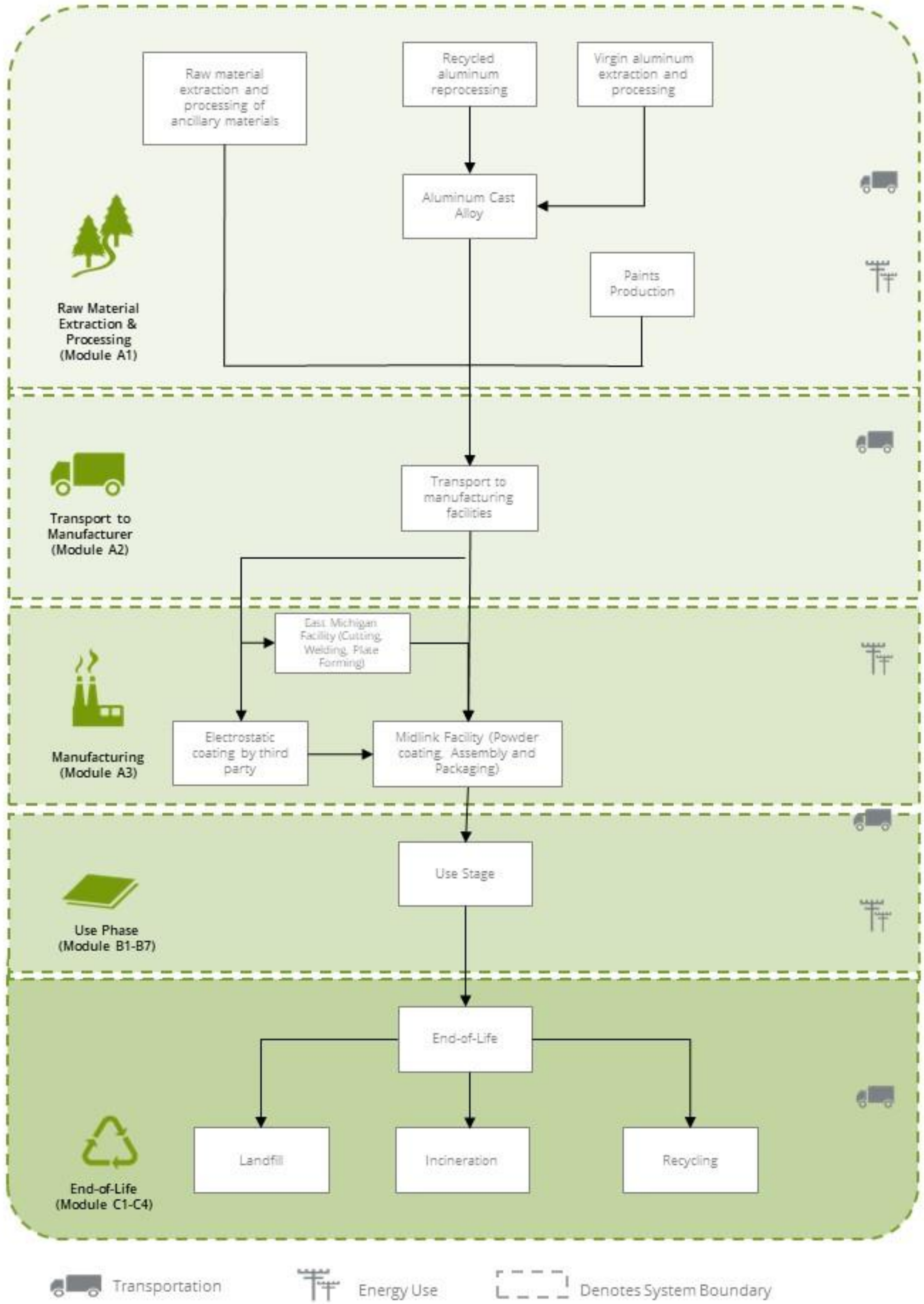

Figure 4. *Process flow diagram to summarize processes and life cycle stages for the Chipman Chair.*

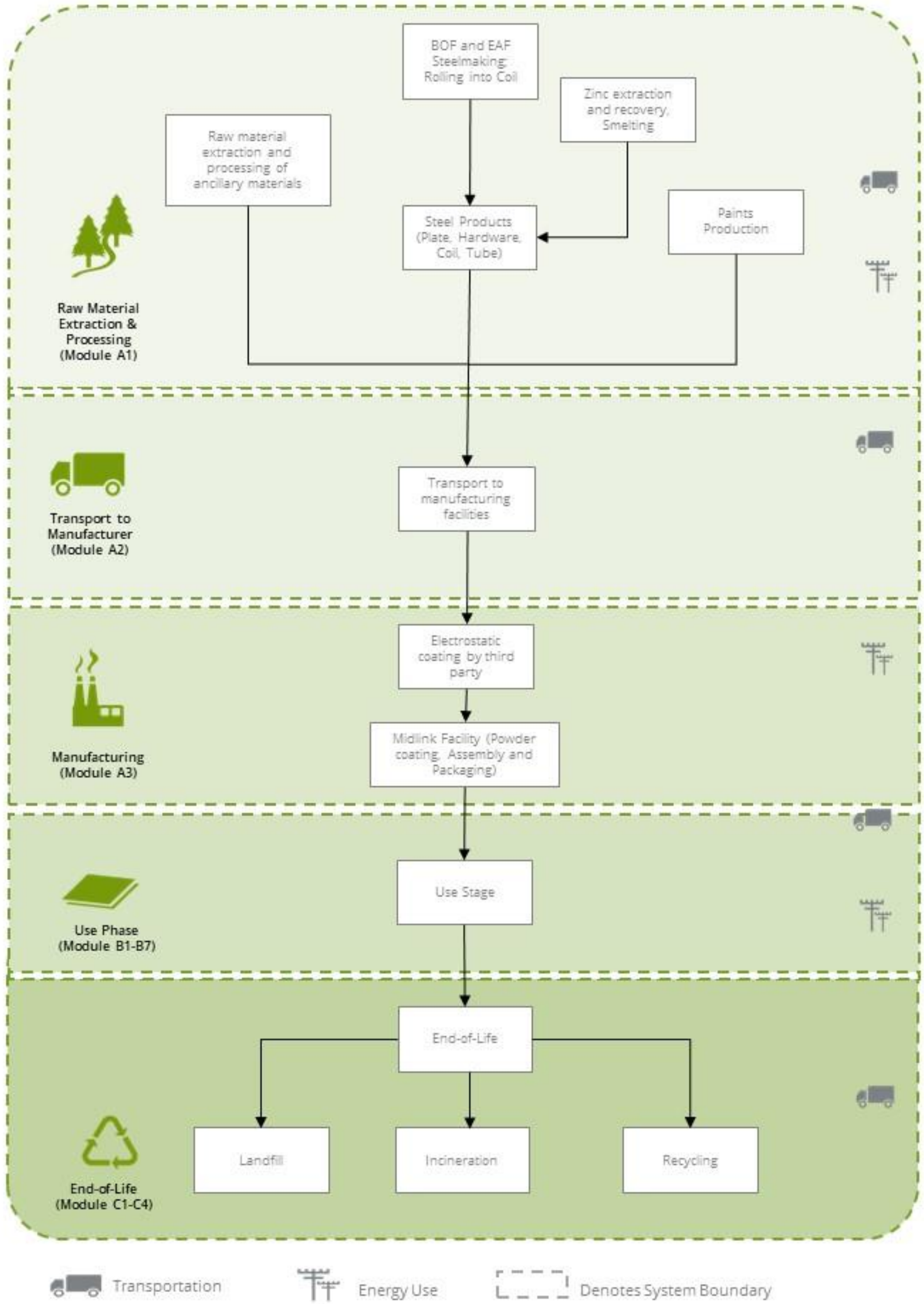

Figure 5. *Process flow diagram to summarize processes and life cycle stages for the Parc Centre Chair.*

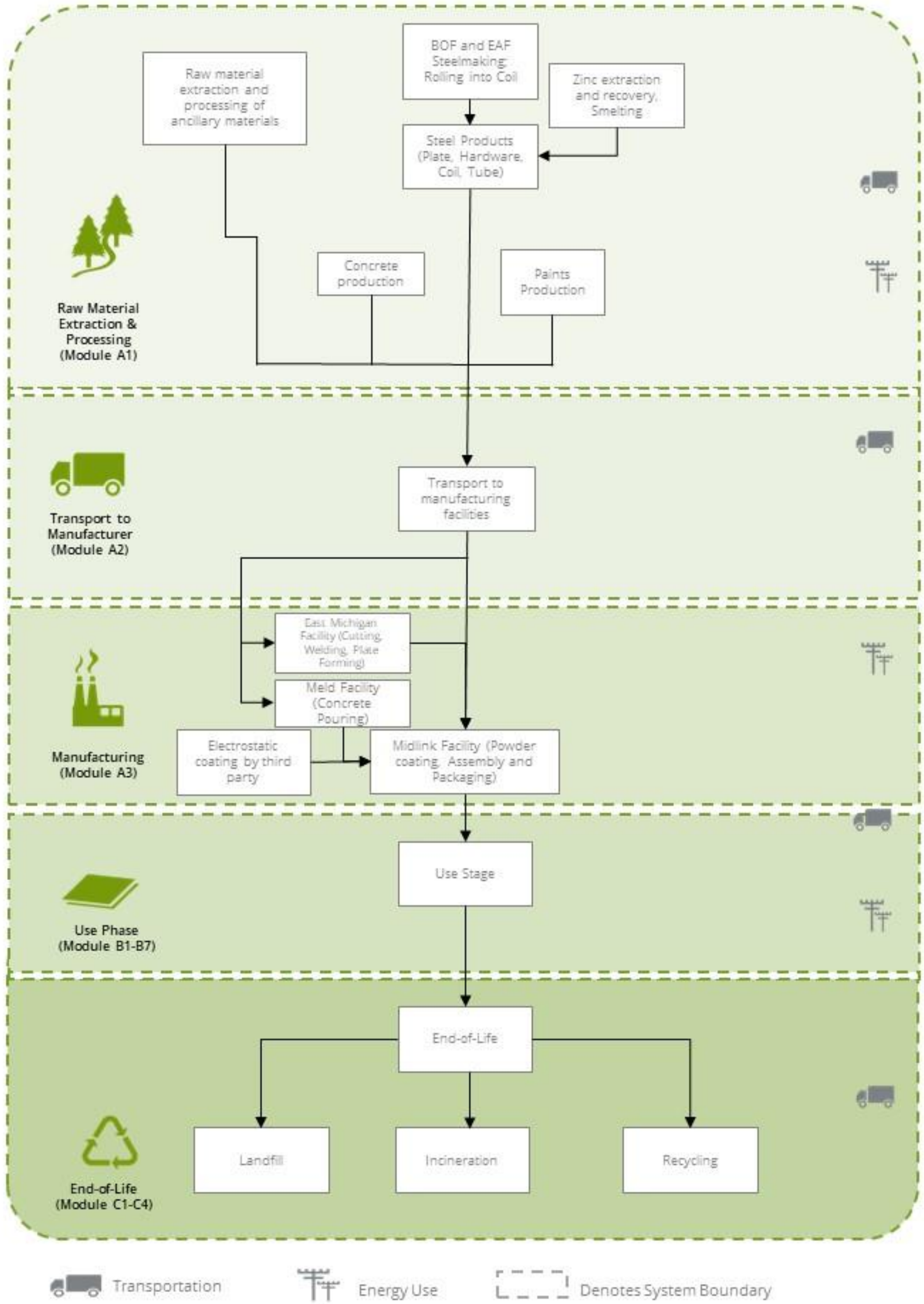

Figure 6. *Process flow diagram to summarize processes and life cycle stages for the Strata Bench.*

2.5 Allocation Procedures

The furniture products are manufactured at the Landscape Forms and Loll Designs facilities. All electricity and resources used at the manufacturing facilities are attributed to the products on a per unit basis, except for welding operations which are modeled on the basis of length of weld. Mass allocation was not possible due to data constraints. Ancillary materials related to powder coating at Midlink (a Landscape Forms facility containing wood working and powder coating operations) are estimated by surface area. Electrostatic coating processes at the third party facility are modeled based on the surface area of the coated portion of the product.

Impacts from transportation were allocated based on the mass of material and distance transported.

Per the PCR, the polluter pays principle is applied to the product systems in which the generator of the waste carries the environmental impact until the point in the product's life cycle at which the waste is transported to a scrapyard or gate of waste processing. Benefits from recovery operations at the end of life of these materials are not attributed to the product system.

2.6 LCIA Methodology and Interpretation Used

. The impact indicators specified under this EPD include:

- Potential for Global Warming,
- Acidification Potential,
- Eutrophication Potential,
- Ozone Depletion Potential,
- Photochemical Ozone (smog) Creation Potential.
- Ecotoxicity,
- Human Toxicity, and
- Land Use/Land Occupation

Impact category indicators for acidification, eutrophication, ozone depletion potential and photochemical ozone creation are estimated using the characterization factors[5], as prescribed by the PCR, including from CML-IA and ReCiPe methodologies as well as those defined by EN 15804.

Table 3. Impact category indicators for the LCIA of the Landscape Forms products.

Category Indicator	Method & Version	Units	Impact Category and Environmental Mechanism
Global Warming Potential (GWP)	GWP100, EN 15804. August 2021.	kg CO_2 eq.	Anthropogenic emissions of greenhouse gases and short-lived climate forcers have led to increased radiative forcing, which has in turn increased the global mean temperature by above 0.99°C since pre-industrial times. All IPCC scenarios project an increase to 1.5°C in the near term, occurring between 2021 to 2040. The projection for the SSP2-4.5 scenario estimates an increase of 2.0°C occurring between 2043-

[5] https://www.environdec.com/resources/indicators

Category Indicator	Method & Version	Units	Impact Category and Environmental Mechanism
			2062, with 3°C occurring between 2061-2080[6]. As global mean temperatures continue to climb, global climate change will result. Some of the predicted impacts include reductions in food and food supplies, water supplies, and sea level rise.[7] Note: WMO Statement of the Global Climate 2021 (18 May 2022) is reporting as an update to the IPCC AR6 WGI, that the average global temperature in 2021 was ~1.11 (±0.13) °C above pre-industrial levels.[8]
Ozone Layer Depletion (ODP)	ODP, EN 15804. August 2021.	kg CFC-11 eq.	Emissions of ozone depleting substances such as chlorofluorocarbons contribute to a thinning of the stratospheric ozone layer. This can lead to increased cases of skin cancer, and effects on crops, other plants, marine life, and human-built materials. All chlorinated and brominated compounds stable enough to reach the stratosphere can have an effect. CFCs, halons and HCFCs are the major causes of ozone depletion. Damage to the ozone layer reduces its ability to prevent ultraviolet (UV) light entering the earth's atmosphere, increasing the amount of carcinogenic UVB light reaching the earth's surface. Due to the international ban on ozone depleting chemicals, the stratospheric ozone layer has begun to recover; U.S. EPA projects that the ozone layer will recover within about 50 years.
Photochemical Oxidant Creation Potential (POCP)	POCP, LOTOS-EUROS as applied in ReCiPe, EN 15804. August 2021.	kg NMVOC eq	Photochemical ozone, also called "ground level ozone", is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. If ozone concentrations reach above certain critical thresholds, health effects in humans can result, including bronchitis, asthma, and emphysema. The impact category depends largely on the amounts of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxide (NO), ammonium and NMVOC (non-methane volatile organic compounds).
Acidification (AP)	AP, accumulated exceedance, EN 15804. August 2021	kg SO_2 eq.	Acidification is the increasing concentration of hydrogen ion (H^+) within the local environmental and occurs as a result of adding acids such as nitric acid and sulfuric acids into the environment. Acid precursor emissions transport in the atmosphere and deposit as acids. These acids may deposit in soils which are sensitive, or insensitive, to the increased acid burden; sensitivity can depend on a number of factors. In acid-sensitive soils, the deposition can decrease the soil pH (acidification) and increase the mobility of heavy metals in the environment, such as aluminum. This acidification can affect the pH of local soils and freshwater bodies, by increasing local hydrogen ion concentrations, causing endpoints such as tree die-offs and dead lakes. Emissions of sulfur dioxide and nitrogen oxides from the combustion of fossil fuels have been the greatest contributor to acid rain.
Eutrophication (EP)	EP, aquatic freshwater, EUTREND model; EP, aquatic marine, EUTREND model; EP, terrestrial, accumulated exceedance	kg PO_4 eq. kg N eq.	Eutrophication is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity. In some regions, emissions of excess nutrients (including phosphorus and nitrogen) into water can lead to increased algal blooms. These blooms can reach such a severity that waterways become choked, with no other plant life able to establish itself. If algal blooms are intense enough, the decaying algae consumes dissolved oxygen in the water column starving other organisms of needed oxygen. Whereas phosphorous is mainly responsible for eutrophication in freshwater systems, nitrogen is mainly

[6] Technical Summary. IPCC AR6 WGI. Box TS.1 https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_TS.pdf

[7] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf

[8] https://public.wmo.int/en/media/press-release/four-key-climate-change-indicators-break-records-2021

Category Indicator	Method & Version	Units	Impact Category and Environmental Mechanism
	EN 15804. August 2021.		responsible for eutrophication in ocean water bodies. Emissions of ammonia, nitrates, nitrogen oxides and phosphorous to air or water all have an impact on eutrophication.
Abiotic Depletion, elements (ADPE)	ADP minerals & metals, EN 15804. August 2021.	kg Sb eq.	This impact category refers to the consumption of non-biological resources such as minerals and metals. The value of the abiotic resource consumption of a substance is a measure of the scarcity of a substance and depends on the amount of resources and the extraction rate. The indicator is calculated as the amount of resources that are depleted and measured in antimony equivalents for mineral depletion.
Abiotic Depletion, fossil fuels (ADPF)	ADP fossil resources, EN 15804. August 2021.	MJ	This impact category refers to the consumption of fossil fuels. The value of the abiotic resource consumption of a substance (e.g., lignite or coal) is a measure of the scarcity of a substance and depends on the amount of resources and the extraction rate. It is calculated as the amount of resources that are depleted and measured in equivalent MJ of fossil fuels.
Ecotoxicity	USEtox 2.02, 2008	CTUe	This category concerns effects of toxic substances on the fresh water aquatic environment. The characterization factor of ecotoxicity accounts for the environmental persistence (fate) and toxicity (effect) of a chemical. The damage (endpoint) level ecotoxicity potential [PDF m^3 d] or comparative damage units [CDUe] per kg chemical emitted represents an increase in the fraction of species potentially disappearing as a consequence of an emission in a compartment
Human Toxicity	USEtox 2.02, 2008	CTUh	This category concerns effects of toxic substances on the human environment. The USEtox model calculates characterization factors for carcinogenic impacts, non-carcinogenic impacts, and total impacts (Carc + non-carc) for chemical emissions to urban air, rural air, freshwater, sea water, agricultural soil and/or natural soil. The characterization factors for human toxicity are expressed in cases/kg.
Land Use	ADP fossil resources, EN 15804. August 2021.	Pt	This impact category quantifies the amount of agricultural, urban or natural land occupied for a certain time.
Water Deprivation Potential (AWARE)	AWARE. EN 15804. August 2021	m^3 depriv	The AWARE method is based on the inverse of the difference between water availability per area and demand per area. It quantifies the potential of water deprivation, to either humans or ecosystems, and serves in calculating the impact score of water consumption at midpoint in LCA or to calculate a water scarcity footprint as per ISO 14046. It is based on the available water remaining (AWARE) per unit of surface in a given watershed relative to the world average, after human and aquatic ecosystem demands have been met. The resulting CF ranges between 0.1 and 100 and is meant to be multiplied with the local water consumption inventory.

Table 4. Disclaimers for environmental indicators as required by the PCR.

Classification	Indicator	Disclaimer
ILCD Type 1	Global warming potential (GWP)	none
	Depletion potential of the stratospheric ozone layer (ODP)	none
	Potential incidence of disease due to PM emissions (PM)	none
ILCD Type 2	Acidification potential, Accumulated Exceedance (AP)	none
	Eutrophication potential, Fraction of nutrients reaching freshwater end compartment (EP-freshwater)	none
	Eutrophication potential, Fraction of nutrients reaching marine end compartment (EP-marine)	none
	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	none
	Formation potential of tropospheric ozone (POCP)	none
	Potential Human exposure efficiency relative to U235 (IRP)	1
ILCD Type 3	Abiotic depletion potential for non-fossil resources (ADP-minerals&metals)	2
	Abiotic depletion potential for fossil resources (ADP-fossil)	2
	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	2
	Potential Comparative Toxic Unit for ecosystems (ETP-fw)	2
	Potential Comparative Toxic Unit for humans (HTP-c)	2
	Potential Comparative Toxic Unit for humans (HTP-nc)	2
	Potential Soil quality index (SQP)	2

Disclaimer 1: *This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.*
Disclaimer 2: *The results of this environmental impact indicator shall be used with care as uncertainties on these results are high or as there is limited experience with the indicator.*

The PCR requires that several other parameters be reported in EPDs, including resource use, waste categories and output flows, and other environmental information. Many of these additional parameters seek to classify resources and materials with respect to their use as raw materials for the product. While the LCA model tracks the input of these elementary flows, the model does not explicitly track whether those energy flows are used to generate energy (e.g., natural gas-based electricity) or used in a product (e.g., fossil based plastics). In such cases, reported results are based on a classification of elementary flows. Elementary flows were reviewed for resources which are considered renewable on a human time scale. Elementary flows related to use of wood, land occupation, and minerals, were not included. Water consumption was not included since this flow is reported separately Based on this classification process, no primary renewable energy resources used as raw materials are estimated for the product system under consideration.

In light of the above discussion, the additional parameters were assessed using the following methods:

- *Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPR_E).* Since there is no classification scheme available in OpenLCA 2.0.1 to account for this parameter, it is estimated using the Cumulative Energy Demand, Lower Heating Value (CED LHV) methodology as indicated in the ACLCA ISO 21930 guidance.[9]

- *Use of renewable primary energy resources used as raw materials (RPR_M).* Although no classification scheme is available in OpenLCA for this parameter, the main consumption in the product system is the use of wood in the furniture product.
- *Total Use of renewable primary energy resources.* This parameter is the total use of renewable primary energy resources estimated as the total renewable Cumulative Energy Demand.
- *Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials ($NRPR_E$).* Since there is no classification scheme available in OpenLCA 2.0.1 to account for this parameter, it is estimated using the Cumulative Energy Demand, Lower Heating Value (CED LHV) methodology as indicated in the ACLCA ISO 21930 guidance.
- *Use of non-renewable primary energy resources used as raw materials ($NRPR_M$).* Although no classification scheme is available in OpenLCA for this parameter, no non-renewable energy resources used as raw materials are used in the product system based on a review of the material content of the products, as described above.
- *Total Use of non-renewable primary energy resources.* This parameter is the total use of non-renewable primary energy resources estimated as the total non-renewable Cumulative Energy Demand.
- *Use of secondary material (SM).* The product contains steel and aluminum scrap, and as such this is a measure of the use of scrap in the product.
- *Use of renewable and non-renewable secondary fuels (RSF/NRSF).* The main consumption of any secondary fuel in the product system is the combustion of municipal solid waste, used to generate electricity in some regions. This parameter is assumed negligible for the current assessment, and reported as zero.
- *Net use of fresh water (FW).* Net use of fresh water (consumption) is included in the EN15804 datasets used for the modeling and are reported for all modules. Water consumption includes evaporation, transpiration, product integration and discharge into a different drainage basin or the sea.
- *Hazardous waste disposed (HWD).* All flows of hazardous waste included in the full LCI and other data sources were aggregated into a single result for total hazardous waste disposal.
- *Non-hazardous waste disposed (NHWD).* This includes all wastes produced across all life cycle stages included in the study scope. Flows of non-hazardous waste included in the full LCI were also aggregated into a single result for total non-hazardous waste disposal.

[9] ACLA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017. May 2019.

- *Radioactive wastes disposed (HLRW/ILLRW).* All flows of radioactive wastes included in the full LCI and other data sources were classified and reported as a single result for total radioactive waste.
- *Components for re-use (CRU).* There are no components of the product which can be reused at the end of the reference service lifetime and this parameter is reported as zero.
- *Materials for recycling (MR)*. This parameter, as reported, includes recycled materials of the product and packaging at end-of-life based on the recycling rates as specified by the 2018 US EPA Facts and Figures report.[10]
- *Materials for energy recovery (MER).* The production of materials for energy recovery crossing the system boundaries is assumed to be negligible, and reported as zero.
- *Recovered energy (RE).* The production of materials for energy recovery crossing the system boundaries is negligible and are assumed zero.
- *Exported energy (EE).* The recovered energy crossing the system boundaries is negligible and are assumed zero.

All results are calculated using the OpenLCA v2.0.1 model utilizing the associated EN 15804+A2 method pack.

The interpretation phase conforms to ISO 14044 with further guidance from the ILCD General Guide for Life Cycle Assessment[11]. The interpretation included the use of evaluation and sensitivity checks to steer the iterative process during the assessment, and a final evaluation including completeness, sensitivity, and consistency checks, at the end of the study.

2.7 Data Requirements

This study included several key data requirements:

- Primary data on Landscape Forms' product materials, packaging materials, suppliers, transportation distances. Pre-consumer and post-consumer recycled content was additionally provided for aluminum, steel, concrete and cardboard components for Landscape Forms products.
- Number of units and mass of units produced at each of the facilities.
- An SDS for the concrete pre-mix used at Meld and an SDS for the thread sealant used in Loll Designs products were provided.

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[10] US EPA, 2020. Advancing Sustainable Materials Management: 2018 Fact Sheet. https://www.epa.gov/sites/default/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf

[11] European Joint Research Commission. International Reference Life Cycle Data System handbook. *General guide for Life Cycle Assessment – Detailed Guidance.* © European Union, 2010.

- Surface area of the powder coated and electrostatic coated products, length of welding for each welded product. Type of welding process was additionally supplied for each product.
- Primary data for operations at each of the Landscape Forms facilities, including energy use, ancillary materials and waste generation.
- Product-specific datasheets and descriptions, retrieved from Landscape Forms' website, were used to verify product materials and dimensions.
- Representative inventory data for many unit processes, using secondary data from the Ecoinvent[12] life cycle database, with a prioritization for data with the highest degree of representativeness of the actual material or process.
- The USDA Wood Handbook[13] was used to look up densities and moisture contents for Ipe wood to match with EN15804 hardwood datasets based on the information.
- A material specifications sheet from Axalta[14] was used to look up the density of electrocoat to calculate the weight of electrocoat required, based on surface areas available from Landscape Forms.

2.8 Value Choices and Optional Elements

The study avoids the use of value choices in the assessment, as described in ISO 14044, such as normalization, weighting or grouping of indicator results. The study includes a data quality assessment, considered optional under ISO 14044 but required by the PCR.

2.9 Cut-off Criteria

The cut-off criteria for including or excluding materials, energy, and emissions data from the study are in accordance with the PCR and are listed below.

- All inputs and outputs to a unit process are included in the LCA calculation for which data are available. Any data gaps are filled with representative data. Assumptions used for filling data gaps are documented in the LCA report.

- Where there is a data gap or insufficient data, criteria for exclusion of inputs and outputs is 1% of primary energy usage (renewable and non-renewable energy) and 1% on a mass basis for the specific unit process. The maximum criteria for exclusion of inputs and outputs is 5% of primary energy usage and mass across all modules included in the LCA.

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[12] EN15804 Add-On. Swiss Center for Life Cycle Inventories http://www.ecoinvent.org

[13] Wood Handbook: Wood as an Engineering Material (2010). United States Department of Agriculture. https://www.fpl.fs.usda.gov/documnts/fplgtr/fpl_gtr190.pdf

[14] https://23433258.fs1.hubspotusercontent-na1.net/hubfs/23433258/Winona_Powder_Coating_December_2022/Pdf/Electrocoat-Aqua-EC-6100.pdf

- If a flow meets the above criteria for exclusion but is considered to have a significant potential environmental impact, it is included.

2.10 Assumptions and Limitations

One of the primary goals of the study is to prepare a life cycle assessment for each of the five Landscape Forms and Loll Designs products; the overarching data quality requirements are to enable a reliable assessment of the indicator results, with data quality sufficient as to identify the key unit processes, differentiated by overall contribution to final results. No data gaps were allowed which were expected to significantly affect the outcome of indicator results. Some individual parts or processes were modeled using the EN15804 datasets for representative materials and processing.

A description of the assumptions leading to the key study limitations is provided in Section 3.

There were several limitations of the study. None of these limitations were judged to have significant relevance to final indicator results, and were deemed acceptable limitations:

Limitations in the Study Scope

- Impact indicators rely on the use of generic models and potential impacts and therefore are not able to measure actual environmental impacts. Additionally, the indicators prescribed by the PCR do not represent all categories of potential environmental and human health impacts associated with the life cycle of Landscape Forms and Loll products, and this represents a general limitation of the LCA study.
- Lacking detailed supplier information, much of the upstream raw materials extraction and processing could not be modeled with actual process information. Representative data from the EN15804 database was utilized as appropriate.
- No specific data were available to estimate the final disposition of the product and packaging at end-of-life. Disposal statistics, including recycling rates for durable goods and packaging were based on regional data. End-of-Life assumptions used in the modeling are described in more detail in Section 2.15 below.

Limitations in Life Cycle Impact Assessment Phase

There are several important limitations in the LCIA methodologies used, which are based upon the requirements of the PCR. There may be additional impacts relevant to the production of the Landscape Forms and Loll Designs products at the manufacturing facility. Some of these omitted impact categories are listed in Table 6. This list is not exhaustive; there may be other impact categories which are not included.

Table 5. Impact categories indicators from the LCIA of the Landscape Forms products.

Core Impact Category Indicators	
Global Warming Potential - Total	Eutrophication Potential, fraction of nutrients reaching freshwater end compartment
Global Warming Potential – Fossil Fuels	Eutrophication potential, Accumulated Exceedance
Global Warming Potential - Biogenic	Formation potential of tropospheric ozone
Global Warming Potential – Land use and land use change	Abiotic depletion potential for non-fossil resources
Depletion potential of the stratospheric ozone layer	Abiotic Depletion potential for fossil resources
Acidification potential, Accumulated Exceedance	Water (user) deprivation potential, deprivation weighted water consumption

Table 6. Additional impact categories indicators from the LCIA of the Landscape Forms products.

Additional Impact Category Indicators
Potential incidence of disease due to PM emissions
Potential Human exposure efficiency relative to U235
Potential Comparative Toxic Unit for ecosystems
Potential Comparative Toxic Unit for humans
Potential Soil quality index

It should also be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Limitations in Results for Other Parameters

The PCR allows for the results for several inventory flows related to the assessed products to be reported as “other parameters”. These are aggregated inventory flows, and do not characterize any potential impact; results should be interpreted taking into account this limitation.

2.11 Data Quality Requirements

One of the primary goals of the study is to prepare an EPD for each of the five Landscape Forms and Loll Designs products; the overarching data quality requirements are to enable a reliable assessment of the indicator results, with data quality sufficient as to identify the key unit processes, differentiated by overall contribution to final results.

No data gaps were allowed which were expected to significantly affect the outcome of indicator results. Some individual parts were modeled using the EN15804 datasets for representative materials and processing.

2.12 Type of Critical Review

This LCA report *will be* critically reviewed by an external LCA expert not involved with the execution of this study, in conformance with ISO 14044 following ISO 14071. This critical review is to occur prior to EPD verification. The critical review report and checklist is to be amended to this LCA report.

2.13 Product Composition

The product system examined in this study includes the cradle-to-grave impacts of the five Landscape Forms products. The mass and a description of each component was provided by Landscape Forms, as well as a breakdown of the major components for each product as described in Tables 7 and 8.

The primary materials used in Landscape Forms products include aluminum, various steel components, wood (Ipe), powder coating materials, various plastics, and concrete. The packaging materials for each product was provided by Landscape Forms and includes wooden pallets, various plastics and corrugated cardboard.

Table 7. Material components for the Landscape Forms products (kg/product).

Product	Product Material							Packaging Materials			
	Aluminum	Steel	Plastics	Concrete	Wood	Coating	Total Product	Wood	Cardboard	Plastic	Total Packaging
Chipman Chair	8.76	0.0	0.0	0.0	0.0	0.545	**9.31**	2.18	3.84	0.0312	**6.05**
	94%	0%	0%	0%	0%	6%	**100%**	36%	63%	1%	**100%**
Parc Centre Chair	0.00	11.0	0.0	0.0	0.0	0.409	**11.5**	2.18	3.47	0.0312	**5.68**
	0%	96%	0%	0%	0%	3%	**100%**	38%	61%	1%	**100%**
FGP Bench	15.2	0.5	0.0	0.0	29.8	0.726	**46.3**	10.9	18.3	0.268	**29.5**
	33%	1%	0%	0%	64%	2%	**100%**	37%	62%	1%	**100%**
AD100 Strata Bench	0.00	45.3	0.0	170.3	0.0	0.590	**216**	99.7	0.0	0.0	**99.7**
	0%	21%	0%	79%	0%	0%	**100%**	100%	0%	0%	**100%**

Table 8. Material components for the Loll Designs products (kg/product).

Product	Product Material						Packaging Material	
	HDPE	Aluminum	Steel	Other	Paper Composite	Product Total	Corrugated	Packaging Total
Adirondack Chair	18.3	0.0434	0.281	0.00278	--	**18.6**	1.54	**1.54**
	98%	0%	2%	0%	--	**100%**	100%	**100%**

2.14 Product Maintenance and Use

No specific maintenance of the product is identified by the manufacturer. It is assumed any impacts associated with routine cleaning and maintenance are minimal and are not included in the LCA model for the product life cycle. Impacts related to indoor air quality during the product use phase are also excluded.

2.13 Transportation and Distribution

Transportation of raw materials to the Landscape Forms facilities is based on primary data supplied by Landscape Forms. Data for transportation upstream of the 1st tier suppliers is included based on assumptions on supply chains embedded in the Ecoinvent EN15804 datasets.

Transportation impacts will vary based on how far the final customer is from the Landscape Forms facility. As such, the transportation of the product and packaging to the final user is modeled based upon the guidance documents' prescription to model truck transport for 1,000 km in the absence of primary data.

Transportation for end-of-life scenarios was modeled using the US EPA WARM model assumption of 20 miles (~32 km), from the point of product use to a landfill, material recovery center, or waste incinerator.

2.15 End-of-Life

End-of-life disposal pathways are modeled by material in line with US statistics for waste disposal, as taken from the 2018 US EPA Facts and Figures report. The disposal rates for the product materials are taken from the durable goods statistics, while the packaging disposal rates are taken from the packaging statistics by material. Concrete in the Landscape Forms products are modeled after the "other materials" category. The construction and demolition section of this report indicates over 80% of concrete materials are reused or recycled, and as such the remainder of concrete in the Landscape Forms products are modeled as recycled or reused.

Table 9. Disposal pathways by material for products and packaging materials at end-of-life.

Material	Product			Packaging		
	Landfill	Incineration	Recycling/ Reuse	Landfill	Incineration	Recycle
Aluminum	84.6%	15.4%	0.0%	--	--	--
Steel	59.2%	13.0%	27.8%	--	--	--
Plastics	--	--	--	69.5%	16.9%	13.6%
Concrete	25%*	0.0%	75%	--	--	--
Wood	81.9%	18.1%	0.0%	65.7%	16.0%	18.3%
Corrugated	--	--	--	15.4%	3.7%	80.9%

3. Life Cycle Modeling and Inventory Analysis

The life cycle inventory (LCI) of each unit process comprises energy inputs, material flows, emissions, wastes, and product outputs associated with the operation. Data sources for these inventories include data provided by the manufacturer, as well as representative data from the EN15804 LCI database.

Environmental flows from the LCI modeling are used to calculate greenhouse gas indicators in the Life Cycle Impact Assessment (LCIA) phase, discussed in Section 4 below.

3.1 Assumptions and Data Sources

The assessment relied on several assumptions related to production and end-of-life emissions. The major assumptions used in the study are described below.

- The Kalamazoo, Michigan production facilities are located in the RFCM eGRID EPA subregion.

The Duluth, Minnesota facility, in which Loll products are manufactured, is located in the MROW eGRID EPA subregion. Ecoinvent EN15804 inventory datasets for the corresponding regions, RFC and MRO, were modified to reflect the eGRID[15] subregion energy mixes to estimate greenhouse gas emissions from electricity use at the facilities. All electricity datasets include upstream, use and downstream emissions.

- Electricity and natural gas use for the office space at East Michigan were accounted for using the area of office space at East Michigan and the average electricity and natural gas use per sq ft in the US[16].
- Additionally, electricity and natural gas use associated with welding at the facility were estimated by using the amount of welding required for one product, the allocation factor for the modeled products versus total production at East Michigan, and the energy consumption per length (m) from the Ecoinvent EN15804 datasets. In this way, welded products were modeled using the average electricity use per welding length and products which do not undergo welding were not assigned any of the electricity and natural gas use associated with welding.
- Powder coating ancillary resource requirements not provided by Landscape Forms were modeled based upon the area of the powder coated surface of each product using Ecoinvent EN15804 datasets. Likewise welding resource requirements were modeled using the Ecoinvent EN15804 dataset and the actual length of welded surface. Electricity and natural gas from welding were allocated to the relevant products by length and removed from the overall resource requirements of the facility.
- Landscape Forms provided primary data for the production facility operations based on representative 2021 production data. The source of secondary LCI data is the Ecoinvent EN15804 databases[17].
- Per the PCR, each material dataset was modified to use the supplier's country-specific electricity dataset, and sub-national datasets were applied when available in the Ecoinvent EN15804 database.
- Much of the upstream raw materials extraction and processing could not be modeled with actual process information. Representative data from the Ecoinvent EN15804 LCI databases were utilized as appropriate. Some individual pieces were modeled by their major materials and approximate masses using representative products. A conservative approach was used for modeling product mass in cases with less certainty.

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[15] The Emissions & Generation Resource Integrated Database (eGRID). US EPA. http://www.epa.gov/cleanenergy/energy-resources/egrid/

[16] Commercial Buildings Energy Consumption Survey (CBECS) (2018). US Energy Information Administration. https://www.eia.gov/consumption/commercial/

[17] Ecoinvent Centre (2021) Ecoinvent data from Swiss Center for Life Cycle Inventories, Dübendorf, 2021 http://www.Ecoinvent.org

- The recycled content of each aluminum component was provided by Landscape Forms. An existing Ecoinvent EN15804 dataset for cast aluminum was modified to represent the secondary and primary aluminum content provided by Landscape Forms. Recycled content for HDPE was provided for Loll Designs products, but not for metals or packaging materials, which constitute a smaller proportion of the Loll Designs products.
- Steel datasets were developed using some representative secondary data sources for hot-dipped galvanized steel from the AISI report, "Life Cycle Inventories of North American Steel Products."[18] For some products, the length of steel tube purchased was based upon the dimensions of the product.
- Technology of steelmaking for steel components produced in China and the United States were based on the report "2022 World Steel in Figures.[19]"
- Zinc-coated materials were based on SDSs retrieved for the coating material, modeled with Ecoinvent EN15804 dataset for zinc coating and a conservative estimate of coating per mass. Surface area for various coated hardware materials were estimated based upon the hardware dimensions. A conservative estimate of 0.005 m^2 coating/kg of coated steel was used to model coated steel hardware. This assumption has a small impact on the results, wherein a 10% increase in m^2 coating per coated steel, yields a 0.18% increase in GWP.
- The SDS for the thread sealant used in the Duluth facility was used to model the chemical components with the Ecoinvent EN15804 datasets. The sealant is a small portion of each product.
- The metal components used in Landscape Forms' products are sent for e-coating to a facility in Elkhart, Indiana. Since the weight of electrostatic paint used was not known, primary data on the surface area of powder coated and e-coated components and secondary data on the thickness and density of electrocoat was used to calculate the amount of electrocoat used, and account for the impact of the electrostatic paint.
- For modeling concrete, supplier data was used to modify the Ecoinvent EN15804 dataset for concrete ready-mix to account for a higher proportion of Portland cement used in the mix for Landscape Forms.
- For module A4, distance for distribution is assumed to be 1,000 km by lorry.
- Transportation for end-of-life scenarios in modules A5 and C2 was modeled using the US EPA WARM model assumption of 20 miles (~32 km), from the point of product use to a landfill, material recovery center, or waste incinerator.
- No use-phase activities are included within the assessment, as no maintenance or energy use

[18] Sphera on behalf of the American Iron and Steel Institute (AISI). (2020) Life Cycle Inventories of North American Steel Products.
[19] World Steel Association. (2022) 2022 World Steel in Figures.

are expected within the lifespan of the products.

- Electricity in A3 Manufacturing is not based on guarantees of origin or similar instruments.
- Module D calculated by modelling the mass of scrap wood pallets fed into the product system per declared unit, as represented by the percent of pallets recycled by Landscape Forms.
- Modules B1 through B7 assumed null.
- For module C4, where the disposal was done by a third party, 80% of non-hazardous wastes are assumed to be disposed in landfill and 20% incinerated.

The datasets shown in Table 10 are used in the openLCA LCA model to represent the manufacture of materials, transportation and end-of-life for the product system.

Table 10. LCI datasets and associated databases used to model the product LCA.

Component	Material Dataset	Data Source	Publication Date
PRODUCTS			
Aluminum			
China/ aluminium, cast alloy	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U± - RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, post-consumer, prepared for recycling, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW	Ecoinvent	2021
US/ aluminium, cast alloy	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U* - RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, post-consumer, prepared for recycling, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW	Ecoinvent	2021
Hardware manufacturing	metal working, average for aluminium product manufacturing | metal working, average for aluminium product manufacturing | Cutoff, U – RoW	Ecoinvent	2021
Extrusion	section bar extrusion, aluminium | section bar extrusion, aluminium | Cutoff, U * - RoW section bar extrusion, aluminium | section bar extrusion, aluminium | Cutoff, U ± - RoW	Ecoinvent	2021
Sheet rolling	sheet rolling, aluminium | sheet rolling, aluminium | Cutoff, U* - RoW sheet rolling, aluminium | sheet rolling, aluminium | Cutoff, U± - RoW	Ecoinvent	2021
Woods			
hardwood	24olymeri, board, hardwood, u=10% | sawnwood, board, hardwood, dried (u=10%), planed | Cutoff, U – RoW	EN15804	2021
Steel datasets			
US Low-alloyed/ Carbon Steel	steel production, converter, low-alloyed | steel, low-alloyed | Cutoff, U RER* steel production, electric, low-alloyed | steel, low-alloyed | Cutoff, U – Europe without Switzerland and Austria*	Ecoinvent	2021

Component	Material Dataset	Data Source	Publication Date
China Low-alloyed/ Carbon Steel	steel production, converter, low-alloyed | steel, low-alloyed | Cutoff, U | - RoW ± steel production, electric, low-alloyed | steel, low-alloyed | Cutoff, U | China – RoW ±	Ecoinvent	2021
Rolling	hot rolling, steel | hot rolling, steel | Cutoff, U | Europe without Austria* hot rolling, steel | hot rolling, steel | Cutoff, U – RoW	Ecoinvent	2021
PO Steel, Galvanized Steel	Each modeled with life cycle inventory from "Life Cycle Inventories of North American Steel Products" From AISI modeled with EN15804 data	AISI	2020
US Stainless Steel	steel production, chromium steel 18/8, hot rolled | steel, chromium steel 18/8, hot rolled | Cutoff, U – RER	Ecoinvent	2021
Hardware mfg	metal working, average for steel product manufacturing | metal working, average for steel product manufacturing | Cutoff, U – RER	Ecoinvent	2021
Channel and Bar mfg	section bar rolling, steel | section bar rolling, steel | Cutoff, U – RER* section bar rolling, steel | section bar rolling, steel | Cutoff, U – RoW±	Ecoinvent	2021
Additional coating	zinc coating, pieces | zinc coat, pieces | Cutoff, U – RER	Ecoinvent	2021
Plastics			
Packaging film	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U – RoW	Ecoinvent	2021
US/ HDPE	polyethylene production, high density, granulate | polyethylene, high density, granulate | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	Ecoinvent	2021
US/LDPE	polyethylene production, low density, granulate | polyethylene, low density, granulate | Cutoff, U – RoW injection moulding | injection moulding | Cutoff, U – RoW*	Ecoinvent	2021
US/Microfoam	polypropylene production, granulate | polypropylene, granulate | Cutoff, U – RoW extrusion, plastic film | extrusion, plastic film | Cutoff, U – RoW*	Ecoinvent	2021
US/Polypropylene	polypropylene production, granulate | polypropylene, granulate | Cutoff, U – RoW injection moulding | injection moulding | Cutoff, U – RoW*	Ecoinvent	2021
US/Vinyl	polyvinylchloride production, bulk 25olymerization | polyvinylchloride, bulk 25olymerizat | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	Ecoinvent	2021
US/ Nylon 6-6	nylon 6-6 production | nylon 6-6 | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	Ecoinvent	2021
China/ Nylon 6-6	nylon 6-6 production | nylon 6-6 | Cutoff, U – RoW± injection moulding | injection moulding | Cutoff, U – RoW±	Ecoinvent	2021
Concrete			
US/ concrete	concrete production, 40Mpa, ready-mix, with Portland cement | concrete, 40Mpa | Cutoff, U – US*	Ecoinvent	2021
Loll Products			
HDPE	polyethylene, high density, granulate, recycled to generic market for high density PE granulate | Cutoff, U – US polyethylene production, high density, granulate, recycled | Cutoff, U – US	Ecoinvent	2021
Aluminum	market for aluminium, cast alloy | aluminium, cast alloy | Cutoff, U – GLO*, ±	Ecoinvent	2021
Stainless Steel	steel production, chromium steel 18/8, hot rolled | steel, chromium steel 18/8, hot rolled | Cutoff, U – RER* metal working, average for steel product manufacturing | Cutoff, U*	Ecoinvent	2021
ST3 Thread Sealant	Modeled using EN15804 datasets and ST3 SDS: acrylic binder production, product in 34% solution state | acrylic binder, without water, in 34% solution state | Cutoff, U – RER kaolin production | kaolin | Cutoff, U – RER	Ecoinvent	2021

Component	Material Dataset	Data Source	Publication Date
		ST3 Sealant SDS provided by Landscape Forms	
Vinyl and Polyurethane	polyvinylchloride production, suspension 26olymerization | Cutoff, U – RER market for polyurethane, flexible foam | Cutoff, U – RER	Ecoinvent	2021
Paper Composite	Richlite EPD	Richlite EPD	
PACKAGING			
Pallets/wood	EUR-flat pallet production | EUR-flat pallet | Cutoff, U – RoW	Ecoinvent	2021
Corrugated cardboard	corrugated board box production | corrugated board box | Cutoff, U - RoW	Ecoinvent	2021
Packaging film	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U – RoW	Ecoinvent	2021
FACILITY			
US-RFC -Grid electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U – Custom RFCM – US-RFC	EI v3.8; EPA eGRID	2021; 2022
Natural gas	heat and power co-generation, natural gas, conventional power plant, 100MW electrical | heat, district or industrial, natural gas | Cutoff, U – US-RFC	Ecoinvent	2021
Welding	welding, arc, aluminium | welding, arc, aluminium | Cutoff, U – RER	Ecoinvent	2022
E-coating	market for electrostatic paint | electrostatic paint | Cutoff, U – GLO	Ecoinvent	2021
WASTES			
Incineration	treatment of municipal solid waste, incineration | municipal solid waste | Cutoff, U – RoW	Ecoinvent	2021
Landfill	treatment of inert waste, sanitary landfill | inert waste | Cutoff, U – RoW	Ecoinvent	2021
TRANSPORTATION			
Road transport	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U – RER	Ecoinvent	2021
Ocean shipping	transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, U – GLO	Ecoinvent	2021
Train transport	market for transport, freight train | transport, freight train | Cutoff, U – US	Ecoinvent	2021
END-OF-LIFE			
Corrugated landfill	treatment of waste paperboard, sanitary landfill | waste paperboard | Cutoff, U – CH	Ecoinvent	2021
Corrugated incineration	treatment of waste paperboard, municipal incineration with fly ash extraction | waste paperboard | Cutoff, U – CH	Ecoinvent	2021
Plastic landfilling	treatment of waste plastic, mixture, sanitary landfill | waste plastic, mixture | Cutoff, U – CH	Ecoinvent	2021
Plastic incineration	treatment of waste plastic, mixture, municipal incineration with fly ash extraction | waste plastic, mixture | Cutoff, U – CH	Ecoinvent	2021
Wood landfill and incineration	treatment of waste wood, untreated, sanitary landfill | waste wood, untreated | Cutoff, U – CH	Ecoinvent	2021
Wood incineration	treatment of waste wood, untreated, municipal incineration with fly ash extraction | waste wood, untreated | Cutoff, U – CH	Ecoinvent	2021
Aluminum	treatment of waste aluminium, sanitary landfill | waste aluminium | Cutoff, U – CH	Ecoinvent	2021
Steel	treatment of scrap steel, municipal incineration with fly ash extraction | scrap steel | Cutoff, U – CH treatment of waste concrete, inert material landfill | waste concrete | Cutoff, U – Europe without Switzerland	Ecoinvent	2021
Concrete	treatment of waste concrete, inert material landfill | waste concrete | Cutoff, U – Europe without Switzerland	Ecoinvent	2021

* modified for US electricity grid
± modified for State Grid Corp of China electricity grid

3.2 Data Quality Assessment

The data quality assessment addresses the following parameters: time-related coverage, geographical coverage, technological coverage, precision, completeness, representativeness, consistency, reproducibility, sources of data, and uncertainty.

Table 11. Data Quality Assessment

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage Age of data and the minimum length of time over which data should be collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data have been updated within the last 5 years (2021 for Ecoinvent). All of the secondary data used represents an average of at least one year's worth of data collection.
Geographical Coverage Geographical area from which data for unit processes should be collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Actual processes for upstream operations are primarily North American or Chinese. Surrogate data used in the assessment for North American operations are representative of North American or European operations. Data representative of European operations are considered sufficiently similar to actual processes. Data for upstream processes in China are modeled with secondary data based on China, where available, of Rest-of-World operations. Electricity grids for secondary datasets are based on the country or sub-national grids, as available in Ecoinvent.
Technology Coverage Specific technology or technology mix	Data are generally representative of the actual technologies used for energy generation, processing, transportation, and manufacturing operations.
Precision Measure of the variability of the data values for each data expressed (e.g. variance)	Precision of results are not quantified due to a lack of data on data variance. Precision on the allocating manufacturing resources is moderate, as subdividing electricity and fuel use by each manufacturing process was not possible. Data collected for most operations were typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results. Precision of the individual component materials could be improved with more primary data.
Completeness Percentage of flow that is measured or estimated	The LCA model includes all known mass and energy flows for production of the five outdoor furniture products. In some instances, surrogate data are used to represent unit processes. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.
Representativeness Qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period, and technology coverage)	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of the outdoor furniture products.
Consistency Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent data for secondary data.
Reproducibility Qualitative assessment of the extent to which information about the methodology and data values would allow an independent	Based on the description of data and assumptions used, the major contributing components and life cycle stages of the assessment would be reproducible by other practitioners with access to the primary data used in the study and the assumptions built into Ecoinvent datasets. These major assumptions, models, and data sources are documented.

Data Quality Parameter	Data Quality Discussion
practitioner to reproduce the results reported in the study	
Sources of the Data Description of all primary and secondary data sources	Data sources used are documented and described in this report. For secondary LCI datasets, Ecoinvent databaseare used. Ecoinvent datasets are also used to underlie some assumptions on welding and coating processes. Other sources of data include the AISI report on steelmaking.
Uncertainty of the Information Uncertainty related to data, models, and assumptions	Uncertainty related to the manufacturing processes are low. Primary data for key unit operations are included. Uncertainty related to the IPCC 2021 metrics are high, given that these metrics assume impacts from climate change will not occur for 100 years and do not include short-lived climate forcers.

3.3 LCI Results

The resource use, waste, and output flows from each step of the product life cycle are provided by module to obtain the life cycle inventory results. Tables 12-16 summarize resource use and waste flows for the Landscape Forms seating products. Results are presented for a single unit of seating product, maintained for a 15 year period.

Aggregated inventory flows were calculated including energy use and waste generation. Where necessary, the lower heating value is used for energy flow calculations.

Life cycle inventory results were reviewed for completeness, consistency and representativeness. In addition, sensitivity analyses for several assumed generic processes were considered. Overall, with respect to those impact categories assessed, the inventory was considered consistent and generally representative of the system processes as the same types of data sources are used throughout, primarily from the manufacturer as well as the Ecoinvent EN15804 database. As noted previously, all known processes and materials of the product system are included in the inventory.

Table 12. Resource use and waste flows by life cycle phase for the Loll Products Adirondack Chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Resources									
Use of nonrenewable primary energy	MJ LHV	150	0.902	188	4.85	2.02×10^{-2}	0.144	0.559	0.00
	%	43.5%	0.3%	54.6%	1.4%	0.0%	0.0%	0.2%	0.0%
Use of nonrenewable primary energy resources used as raw materials	MJ LHV	104	8.54	45.1	45.9	0.140	1.37	3.54	0.00
	%	49.8%	4.1%	21.6%	22.0%	0.1%	0.7%	1.7%	0.0%
Use of renewable primary energy	MJ LHV	17.5	9.96×10^{-2}	32.9	0.535	6.37×10^{-3}	1.59×10^{-2}	0.172	0.00
	%	34.1%	0.2%	64.2%	1.0%	0.0%	0.0%	0.3%	0.0%
Use of renewable primary energy resources used as raw materials	MJ LHV	4.81	3.27×10^{-2}	3.16	0.176	8.38×10^{-4}	5.23×10^{-3}	3.85×10^{-2}	0.00
	%	58.5%	0.4%	38.4%	2.1%	0.0%	0.1%	0.5%	0.0%
Use of net fresh water	m3	9.08×10^{-2}	1.07×10^{-3}	0.101	5.75×10^{-3}	9.04×10^{-5}	1.71×10^{-4}	1.03×10^{-2}	0.00

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
	%	43.4%	0.5%	48.3%	2.8%	0.0%	0.1%	4.9%	0.0%
Use of secondary materials	kg	37.5	9.45×10^{-3}	0.246	5.08×10^{-2}	4.62×10^{-4}	1.51×10^{-3}	1.83×10^{-2}	0.00
	%	99.1%	0.0%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%
Use of Nonrenewable secondary fuels	MJ LHV	0.339	1.15×10^{-2}	0.105	6.16×10^{-2}	3.97×10^{-4}	1.83×10^{-3}	9.57×10^{-3}	0.00
	%	64.1%	2.2%	19.9%	11.6%	0.1%	0.3%	1.8%	0.0%
Use of Renewable secondary fuels	MJ LHV	0.236	2.83×10^{-3}	0.114	1.52×10^{-2}	1.75×10^{-4}	4.52×10^{-4}	4.39×10^{-3}	0.00
	%	63.3%	0.8%	30.5%	4.1%	0.0%	0.1%	1.2%	0.0%
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPRE)	MJ LHV	22.3	0.132	36.1	0.711	7.21×10^{-3}	2.12×10^{-2}	0.210	0.00
	%	37.5%	0.2%	60.7%	1.2%	0.0%	0.0%	0.4%	0.0%
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (NRPRE)	MJ LHV	253	9.45	233	50.8	0.160	1.51	4.10	0.00
	%	45.9%	1.7%	42.2%	9.2%	0.0%	0.3%	0.7%	0.0%
Wastes									
Components for re-use	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exported energy	MJ LHV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials for energy recovery	kg	3.84×10^{-2}	2.17×10^{-3}	1.44×10^{-2}	1.17×10^{-2}	4.35×10^{-5}	3.47×10^{-4}	1.58×10^{-3}	0.00
	%	56.0%	3.2%	21.0%	17.0%	0.1%	0.5%	2.3%	0.0%
Materials for recycling	kg	0.448	7.88×10^{-3}	0.205	4.23×10^{-2}	4.10×10^{-4}	1.26×10^{-3}	3.93×10^{-2}	0.00
	%	60.2%	1.1%	27.5%	5.7%	0.1%	0.2%	5.3%	0.0%
Hazardous waste	kg	41.1	0.208	89.3	1.12	3.88×10^{-3}	3.32×10^{-2}	0.128	0.00
	%	31.2%	0.2%	67.7%	0.8%	0.0%	0.0%	0.1%	0.0%
Nonhazardous waste	kg	3.91	0.479	0.837	2.58	0.140	7.67×10^{-2}	16.5	0.00
	%	16.0%	2.0%	3.4%	10.5%	0.6%	0.3%	67.2%	0.0%
Radioactive waste	kg	3.23×10^{-2}	1.87×10^{-4}	2.49×10^{-2}	1.00×10^{-3}	5.78×10^{-6}	2.99×10^{-5}	1.38×10^{-4}	0.00
	%	55.1%	0.3%	42.5%	1.7%	0.0%	0.1%	0.2%	0.0%

Table 13. Resource use and waste flows by life cycle phase for the Landscape Forms FGP Bench. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Resources									
Use of nonrenewable primary energy	MJ LHV	3,510	12.4	464	18.2	0.650	0.359	1.94	-0.433
	%	87.6%	0.3%	11.6%	0.5%	0.0%	0.0%	0.0%	0.0%
Use of nonrenewable primary energy resources used as raw materials	MJ LHV	637	68.5	623	173	4.34	3.40	6.35	-0.135
	%	42.0%	4.5%	41.1%	11.4%	0.3%	0.2%	0.4%	0.0%
Use of renewable primary energy	MJ LHV	63.6	1.00	23.8	2.01	0.216	$3.97x10^{-2}$	0.625	$-2.96x10^{-2}$
	%	69.7%	1.1%	26.1%	2.2%	0.2%	0.0%	0.7%	0.0%
Use of renewable primary energy resources used as raw materials	MJ LHV	1,030	0.478	148	0.661	$3.26x10^{-2}$	$1.30x10^{-2}$	0.231	$-7.33x10^{-3}$
	%	87.3%	0.0%	12.6%	0.1%	0.0%	0.0%	0.0%	0.0%
Use of net fresh water	m3	1.12	$1.13x10^{-2}$	0.555	$2.17x10^{-2}$	$4.61x10^{-3}$	$4.27x10^{-4}$	$1.26x10^{-2}$	$-4.52x10^{-4}$
	%	65.0%	0.7%	32.1%	1.3%	0.3%	0.0%	0.7%	0.0%
Use of secondary materials	kg	6.61	0.119	23.2	0.191	$1.94x10^{-2}$	$3.77x10^{-3}$	0.144	$-8.11x10^{-3}$
	%	21.8%	0.4%	76.7%	0.6%	0.1%	0.0%	0.5%	0.0%
Use of Nonrenewable secondary fuels	MJ LHV	2.47	$9.35x10^{-2}$	6.37	0.232	$1.05x10^{-2}$	$4.57x10^{-3}$	0.948	$-1.02x10^{-3}$
	%	24.4%	0.9%	62.9%	2.3%	0.1%	0.0%	9.4%	0.0%
Use of Renewable secondary fuels	MJ LHV	0.367	$1.77x10^{-2}$	2.15	$5.71x10^{-2}$	$5.85x10^{-3}$	$1.13x10^{-3}$	$1.67x10^{-2}$	$-2.27x10^{-4}$
	%	14.0%	0.7%	82.2%	2.2%	0.2%	0.0%	0.6%	0.0%
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPRE)	MJ LHV	630	1.48	3.80	2.67	0.249	$5.27x10^{-2}$	0.857	$-3.69x10^{-2}$
	%	98.6%	0.2%	0.6%	0.4%	0.0%	0.0%	0.1%	0.0%
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (NRPRE)	MJ LHV	4,150	80.9	1,090	191	4.99	3.76	8.29	-0.568
	%	75.1%	1.5%	19.7%	3.5%	0.1%	0.1%	0.2%	0.0%
Wastes									
Components for re-use	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exported energy	MJ LHV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials for energy recovery	kg	0.265	$5.46x10^{-2}$	0.110	$4.39x10^{-2}$	$1.80x10^{-3}$	$8.64x10^{-4}$	$1.01x10^{-2}$	$-6.70x10^{-3}$
	%	55.2%	11.4%	23.0%	9.1%	0.4%	0.2%	2.1%	-1.4%

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Materials for recycling	kg	0.979	8.44×10^{-2}	3.70	0.159	1.43×10^{-2}	3.14×10^{-3}	1.19	-4.95×10^{-3}
	%	16.0%	1.4%	60.4%	2.6%	0.2%	0.1%	19.5%	-0.1%
Hazardous waste	kg	782	2.59	96.0	4.20	0.120	8.27×10^{-2}	0.454	-8.59×10^{-2}
	%	88.3%	0.3%	10.9%	0.5%	0.0%	0.0%	0.1%	0.0%
Nonhazardous waste	kg	23.3	1.69	6.01	9.69	11.8	0.191	45.5	-5.92×10^{-3}
	%	23.8%	1.7%	6.1%	9.9%	12.0%	0.2%	46.3%	0.0%
Radioactive waste	kg	0.161	1.52×10^{-3}	7.08×10^{-2}	3.78×10^{-3}	1.83×10^{-4}	7.45×10^{-5}	4.31×10^{-4}	-1.61×10^{-5}
	%	67.7%	0.6%	29.8%	1.6%	0.1%	0.0%	0.2%	0.0%

Table 14. Resource use and waste flows by life cycle phase for the Landscape Forms Chipman chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Resources									
Use of nonrenewable primary energy	MJ LHV	1,940	6.67	509	3.70	0.132	7.23×10^{-2}	0.533	-8.67×10^{-2}
	%	78.9%	0.3%	20.7%	0.2%	0.0%	0.0%	0.0%	0.0%
Use of nonrenewable primary energy resources used as raw materials	MJ LHV	309	34.7	555	35.0	0.881	0.685	2.11	-2.70×10^{-2}
	%	33.0%	3.7%	59.2%	3.7%	0.1%	0.1%	0.2%	0.0%
Use of renewable primary energy	MJ LHV	27.6	0.522	23.9	0.408	4.44×10^{-2}	7.98×10^{-3}	0.311	-5.92×10^{-3}
	%	52.3%	1.0%	45.3%	0.8%	0.1%	0.0%	0.6%	0.0%
Use of renewable primary energy resources used as raw materials	MJ LHV	21.9	0.257	41.3	0.134	6.62×10^{-3}	2.62×10^{-3}	0.120	-1.47×10^{-3}
	%	34.3%	0.4%	64.8%	0.2%	0.0%	0.0%	0.2%	0.0%
Use of net fresh water	m3	0.545	5.90×10^{-3}	0.391	4.39×10^{-3}	9.28×10^{-4}	8.58×10^{-5}	3.59×10^{-3}	-9.05×10^{-5}
	%	57.3%	0.6%	41.1%	0.5%	0.1%	0.0%	0.4%	0.0%
Use of secondary materials	kg	3.21	6.30×10^{-2}	9.26	3.87×10^{-2}	3.95×10^{-3}	7.58×10^{-4}	4.92×10^{-2}	-1.62×10^{-3}
	%	25.5%	0.5%	73.3%	0.3%	0.0%	0.0%	0.4%	0.0%
Use of Nonrenewable secondary fuels	MJ LHV	1.20	4.70×10^{-2}	8.08	4.70×10^{-2}	2.17×10^{-3}	9.19×10^{-4}	0.539	-2.04×10^{-4}
	%	12.1%	0.5%	81.4%	0.5%	0.0%	0.0%	5.4%	0.0%
Use of Renewable secondary fuels	MJ LHV	0.126	8.52×10^{-3}	2.73	1.16×10^{-2}	1.20×10^{-3}	2.26×10^{-4}	8.68×10^{-3}	-4.53×10^{-5}
	%	4.4%	0.3%	94.6%	0.4%	0.0%	0.0%	0.3%	0.0%
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPRE)	MJ LHV	49.4	0.779	31.6	0.542	5.11×10^{-2}	1.06×10^{-2}	0.431	-7.39×10^{-3}
	%	59.7%	0.9%	38.1%	0.7%	0.1%	0.0%	0.5%	0.0%

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (NRPRE)	MJ LHV	2,250	41.4	1,060	38.7	1.01	0.757	2.64	-0.114
	%	66.2%	1.2%	31.3%	1.1%	0.0%	0.0%	0.1%	0.0%
Wastes									
Components for re-use	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exported energy	MJ LHV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials for energy recovery	kg	0.118	3.03×10^{-2}	6.36×10^{-2}	8.89×10^{-3}	3.65×10^{-4}	1.74×10^{-4}	1.09×10^{-3}	-1.34×10^{-3}
	%	53.4%	13.7%	28.8%	4.0%	0.2%	0.1%	0.5%	-0.6%
Materials for recycling	kg	0.374	4.41×10^{-2}	4.56	3.23×10^{-2}	2.92×10^{-3}	6.32×10^{-4}	0.652	-9.90×10^{-4}
	%	6.6%	0.8%	80.5%	0.6%	0.1%	0.0%	11.5%	0.0%
Hazardous waste	kg	425	1.38	102	0.851	2.44×10^{-2}	1.66×10^{-2}	0.113	-1.72×10^{-2}
	%	80.2%	0.3%	19.3%	0.2%	0.0%	0.0%	0.0%	0.0%
Nonhazardous waste	kg	12.2	0.708	2.15	1.96	2.38	3.84×10^{-2}	8.77	-1.18×10^{-3}
	%	43.2%	2.5%	7.6%	7.0%	8.4%	0.1%	31.1%	0.0%
Radioactive waste	kg	8.54×10^{-2}	7.69×10^{-4}	8.37×10^{-2}	7.66×10^{-4}	3.75×10^{-5}	1.50×10^{-5}	2.07×10^{-4}	-3.21×10^{-6}
	%	50.0%	0.5%	49.0%	0.4%	0.0%	0.0%	0.1%	0.0%

Table 15. Resource use and waste flows by life cycle phase for the Landscape Forms Parc Center chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Resources									
Use of nonrenewable primary energy	MJ LHV	215	0.330	391	4.13	0.125	8.92×10^{-2}	0.145	-8.67×10^{-2}
	%	35.2%	0.1%	64.0%	0.7%	0.0%	0.0%	0.0%	0.0%
Use of nonrenewable primary energy resources used as raw materials	MJ LHV	109	3.13	459	39.2	0.840	0.845	1.17	-2.70×10^{-2}
	%	17.8%	0.5%	74.8%	6.4%	0.1%	0.1%	0.2%	0.0%
Use of renewable primary energy	MJ LHV	19.2	3.65×10^{-2}	18.2	0.457	4.15×10^{-2}	9.86×10^{-3}	1.21×10^{-2}	-5.92×10^{-3}
	%	50.5%	0.1%	48.1%	1.2%	0.1%	0.0%	0.0%	0.0%
Use of renewable primary energy resources used as raw materials	MJ LHV	9.19	1.20×10^{-2}	36.4	0.150	6.30×10^{-3}	3.23×10^{-3}	5.36×10^{-3}	-1.47×10^{-3}
	%	20.1%	0.0%	79.5%	0.3%	0.0%	0.0%	0.0%	0.0%
Use of net fresh water	m3	0.349	3.92×10^{-4}	0.340	4.91×10^{-3}	8.85×10^{-4}	1.06×10^{-4}	1.36×10^{-3}	-9.05×10^{-5}

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
	%	50.1%	0.1%	48.8%	0.7%	0.1%	0.0%	0.2%	0.0%
Use of secondary materials	kg	10.8	$3.46x10^{-3}$	7.76	$4.33x10^{-2}$	$3.75x10^{-3}$	$9.36x10^{-4}$	$2.15x10^{-2}$	$-1.62x10^{-3}$
	%	57.8%	0.0%	41.8%	0.2%	0.0%	0.0%	0.1%	0.0%
Use of Nonrenewable secondary fuels	MJ LHV	0.530	$4.20x10^{-3}$	6.22	$5.25x10^{-2}$	$2.00x10^{-3}$	$1.13x10^{-3}$	0.138	$-2.04x10^{-4}$
	%	7.6%	0.1%	89.5%	0.8%	0.0%	0.0%	2.0%	0.0%
Use of Renewable secondary fuels	MJ LHV	0.457	$1.03x10^{-3}$	2.09	$1.30x10^{-2}$	$1.12x10^{-3}$	$2.80x10^{-4}$	$2.36x10^{-4}$	$-4.53x10^{-5}$
	%	17.8%	0.0%	81.6%	0.5%	0.0%	0.0%	0.0%	0.0%
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPRE)	MJ LHV	28.3	$4.84x10^{-2}$	21.0	0.606	$4.78x10^{-2}$	$1.31x10^{-2}$	$1.75x10^{-2}$	$-7.39x10^{-3}$
	%	56.6%	0.1%	42.0%	1.2%	0.1%	0.0%	0.0%	0.0%
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (NRPRE)	MJ LHV	325	3.46	850	43.3	0.965	0.935	1.32	-0.114
	%	26.5%	0.3%	69.4%	3.5%	0.1%	0.1%	0.1%	0.0%
Wastes									
Components for re-use	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exported energy	MJ LHV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials for energy recovery	kg	$7.79x10^{-2}$	$7.94x10^{-4}$	$5.32x10^{-2}$	$9.94x10^{-3}$	$3.50x10^{-4}$	$2.15x10^{-4}$	$6.32x10^{-4}$	$-1.34x10^{-3}$
	%	55.0%	0.6%	37.5%	7.0%	0.2%	0.2%	0.4%	-0.9%
Materials for recycling	kg	1.91	$2.89x10^{-3}$	3.91	$3.61x10^{-2}$	$2.73x10^{-3}$	$7.80x10^{-4}$	0.680	$-9.90x10^{-4}$
	%	29.2%	0.0%	59.8%	0.6%	0.0%	0.0%	10.4%	0.0%
Hazardous waste	kg	62.5	$7.60x10^{-2}$	78.6	0.952	$2.32x10^{-2}$	$2.05x10^{-2}$	$2.82x10^{-2}$	$-1.72x10^{-2}$
	%	44.0%	0.1%	55.3%	0.7%	0.0%	0.0%	0.0%	0.0%
Nonhazardous waste	kg	3.60	0.175	2.39	2.20	2.31	$4.74x10^{-2}$	8.03	$-1.18x10^{-3}$
	%	19.2%	0.9%	12.8%	11.7%	12.3%	0.3%	42.8%	0.0%
Radioactive waste	kg	$2.32x10^{-2}$	$6.84x10^{-5}$	$6.41x10^{-2}$	$8.57x10^{-4}$	$3.52x10^{-5}$	$1.85x10^{-5}$	$1.93x10^{-5}$	$-3.21x10^{-6}$
	%	26.3%	0.1%	72.6%	1.0%	0.0%	0.0%	0.0%	0.0%

Table 16. Resource use and waste flows by life cycle phase for the Landscape Forms Strata Bench. Results are shown for one chair maintained for 15 years.

	Unit	A1	A2	A3	A4	A5	C2	C4	D
Resources									
Use of nonrenewable primary energy	MJ LHV	1,050	47.1	533	76.0	2.57	1.68	0.400	$-8.67x10^{-2}$
	%	61.4%	2.7%	31.1%	4.4%	0.1%	0.1%	0.0%	0.0%
Use of nonrenewable primary energy resources used as raw materials	MJ LHV	544	446	582	720	20.5	15.9	4.32	$-2.70x10^{-2}$
	%	23.3%	19.1%	24.9%	30.8%	0.9%	0.7%	0.2%	0.0%
Use of renewable primary energy	MJ LHV	94.1	5.20	25.2	8.39	0.600	0.185	$2.73x10^{-2}$	$-5.92x10^{-3}$
	%	70.4%	3.9%	18.9%	6.3%	0.4%	0.1%	0.0%	0.0%
Use of renewable primary energy resources used as raw materials	MJ LHV	23.5	1.71	39.0	2.75	0.149	$6.07x10^{-2}$	$1.29x10^{-2}$	$-1.47x10^{-3}$
	%	35.0%	2.5%	58.0%	4.1%	0.2%	0.1%	0.0%	0.0%
Use of net fresh water	m3	2.12	$5.59x10^{-2}$	0.411	$9.02x10^{-2}$	$2.07x10^{-2}$	$1.99x10^{-3}$	$5.06x10^{-3}$	$-9.05x10^{-5}$
	%	78.4%	2.1%	15.2%	3.3%	0.8%	0.1%	0.2%	0.0%
Use of secondary materials	kg	45.4	0.494	9.33	0.796	$8.04x10^{-2}$	$1.76x10^{-2}$	$3.17x10^{-3}$	$-1.62x10^{-3}$
	%	80.9%	0.9%	16.6%	1.4%	0.1%	0.0%	0.0%	0.0%
Use of Nonrenewable secondary fuels	MJ LHV	1.85	0.599	8.20	0.965	$1.99x10^{-2}$	$2.13x10^{-2}$	$4.95x10^{-3}$	$-2.04x10^{-4}$
	%	15.9%	5.1%	70.3%	8.3%	0.2%	0.2%	0.0%	0.0%
Use of Renewable secondary fuels	MJ LHV	1.87	0.148	2.75	0.238	$1.59x10^{-2}$	$5.25x10^{-3}$	$4.49x10^{-4}$	$-4.53x10^{-5}$
	%	37.3%	2.9%	54.6%	4.7%	0.3%	0.1%	0.0%	0.0%
Use of renewable primary energy excluding renewable primary energy resources used as raw materials (RPRE)	MJ LHV	118	6.91	-1,470	11.1	0.748	0.246	$4.02x10^{-2}$	$-7.39x10^{-3}$
	%	-8.8%	-0.5%	110.2%	-0.8%	-0.1%	0.0%	0.0%	0.0%
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials (NRPRE)	MJ LHV	1,600	493	1,120	796	23.0	17.6	4.72	-0.114
	%	39.5%	12.2%	27.6%	19.7%	0.6%	0.4%	0.1%	0.0%
Wastes									
Components for re-use	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Exported energy	MJ LHV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials for energy recovery	kg	0.396	0.113	0.412	0.183	$9.55x10^{-3}$	$4.03x10^{-3}$	$9.04x10^{-4}$	$-1.34x10^{-3}$
	%	35.4%	10.1%	36.9%	16.4%	0.9%	0.4%	0.1%	-0.1%

	Unit	A1	A2	A3	A4	A5	C2	C4	D
Materials for recycling	kg	8.09	0.412	5.25	0.664	4.32×10^{-2}	1.46×10^{-2}	2.28×10^{-2}	-9.90×10^{-4}
	%	55.8%	2.8%	36.2%	4.6%	0.3%	0.1%	0.2%	0.0%
Hazardous waste	kg	250	10.8	107	17.5	0.507	0.386	7.77×10^{-2}	-1.72×10^{-2}
	%	64.7%	2.8%	27.7%	4.5%	0.1%	0.1%	0.0%	0.0%
Nonhazardous waste	kg	23.3	25.0	4.65	40.4	73.4	0.891	31.9	-1.18×10^{-3}
	%	11.7%	12.5%	2.3%	20.2%	36.8%	0.4%	16.0%	0.0%
Radioactive waste	kg	9.09×10^{-2}	9.76×10^{-3}	8.60×10^{-2}	1.57×10^{-2}	5.92×10^{-4}	3.47×10^{-4}	5.95×10^{-5}	-3.21×10^{-6}
	%	44.7%	4.8%	42.3%	7.7%	0.3%	0.2%	0.0%	0.0%

4. Life Cycle Impact Assessment (LCIA)

4.1 LCIA Methodology

From the LCI data, impact assessment results are calculated. The choice of methods and indicators used in the assessment are based on the requirements of the EPD Norge® PCRs. It should be noted that the LCIA results presented below are relative expressions and do not predict impacts on category endpoints, exceedance of thresholds, safety margins, or risks associated with the product system. The environmental relevance of LCIA results is not affected by LCI functional unit calculation, system wide averaging, aggregation and allocation. The LCIA and inventory flow results were calculated using the OpenLCA v2.0.1 model.

4.2 Indicator calculations

Impact category indicators are estimated using the characterization methodologies specified by the PCR, including acidification potential, eutrophication potential, photochemical ozone creation potential, abiotic resource depletion potential and global warming potential. Impact indicators results for ecotoxicity, human toxicity and land use are also included in the assessment. Production wastage is modelled based on the product lost less the material sent to landfill and internal/external recycling. Waste in A3 is accounted for in modules A1 and A2 of the model.

It should be noted that the indicators prescribed by the PCR do not represent all categories of potential environmental and human health impact associated with the life cycle of the products, and this represents a general limitation of the LCA study. Additionally, these indicators have no “environmental relevance,” as defined in the ISO-14044 §4.4.2.2.2, 4.4.2.2.4, and 4.4.5, with the exception of the “Potential for Global Warming” indicator, which has low environmental relevance. That is, these “potential” results may or may not have any relationship to actual impacts occurring.

4.3 Contribution Analysis

Life cycle modeling of the Landscape Forms seating products was divided into distinct life cycle phases, including raw material extraction and processing, manufacturing, packaging, transportation, product use and disposal. A detailed examination of the potential environmental impacts provides some insight into the relative contributions from each of the product's life cycle phases. Category indicator results for the Landscape Forms seating products are presented by life cycle phase in Tables 17-26. Modules B1, B2, B3, B4, B5, B6, B7, C1 and C3 are assumed null.

Table 17. Core Life Cycle Impact Assessment Results by life cycle phase for the Loll Products Adirondack chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Core Indicators									
Acidification	molc H+ eq	6.18×10^{-2}	3.12×10^{-3}	5.72×10^{-2}	1.68×10^{-2}	6.92×10^{-5}	4.99×10^{-4}	2.23×10^{-3}	0.00
	%	43.6%	2.2%	40.4%	11.8%	0.0%	0.4%	1.6%	0.0%
Climate change - Biogenic	kg CO2 eq	3.21	1.09×10^{-3}	5.62×10^{-3}	5.86×10^{-3}	0.256	1.75×10^{-4}	3.29×10^{-3}	0.00
	%	92.2%	0.0%	0.2%	0.2%	7.4%	0.0%	0.1%	0.0%
Climate change - Fossil	kg CO2 eq	14.2	0.616	12.0	3.31	1.00×10^{-2}	9.86×10^{-2}	6.82	0.00
	%	38.3%	1.7%	32.4%	8.9%	0.0%	0.3%	18.4%	0.0%
Climate change - Land use and LU change	kg CO2 eq	8.52×10^{-3}	2.44×10^{-4}	2.99×10^{-3}	1.31×10^{-3}	3.74×10^{-6}	3.91×10^{-5}	5.76×10^{-5}	0.00
	%	64.7%	1.9%	22.7%	10.0%	0.0%	0.3%	0.4%	0.0%
Climate Change - Total	kg CO2 eq	17.5	0.617	12.0	3.32	0.266	9.88×10^{-2}	6.83	0.00
	%	43.0%	1.5%	29.6%	8.2%	0.7%	0.2%	16.8%	0.0%
Eutrophication, freshwater	kg PO_4 eq	8.28×10^{-3}	4.03×10^{-5}	1.83×10^{-2}	2.17×10^{-4}	7.31×10^{-7}	6.45×10^{-6}	2.19×10^{-5}	0.00
	%	30.8%	0.1%	68.1%	0.8%	0.0%	0.0%	0.1%	0.0%
Eutrophication, marine	kg N eq	1.64×10^{-2}	1.08×10^{-3}	1.06×10^{-2}	5.78×10^{-3}	2.18×10^{-4}	1.72×10^{-4}	3.05×10^{-2}	0.00
	%	25.4%	1.7%	16.3%	8.9%	0.3%	0.3%	47.1%	0.0%
Eutrophication, terrestrial	molc N eq	0.141	1.17×10^{-2}	7.62×10^{-2}	6.31×10^{-2}	2.32×10^{-4}	1.88×10^{-3}	1.00×10^{-2}	0.00
	%	46.3%	3.9%	25.1%	20.8%	0.1%	0.6%	3.3%	0.0%
Ozone depletion	kg CFC11 eq	1.14×10^{-6}	1.44×10^{-7}	5.54×10^{-7}	7.72×10^{-7}	2.32×10^{-9}	2.30×10^{-8}	5.54×10^{-8}	0.00
	%	42.4%	5.3%	20.6%	28.7%	0.1%	0.9%	2.1%	0.0%
Photochemical ozone formation	kg MVOC eq	4.13×10^{-2}	3.30×10^{-3}	3.23×10^{-2}	1.77×10^{-2}	1.22×10^{-4}	5.28×10^{-4}	2.91×10^{-3}	0.00
	%	42.1%	3.4%	32.9%	18.1%	0.1%	0.5%	3.0%	0.0%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	1.36×10^{-4}	2.07×10^{-6}	2.89×10^{-5}	1.11×10^{-5}	3.71×10^{-8}	3.32×10^{-7}	7.91×10^{-7}	0.00
	%	75.9%	1.2%	16.1%	6.2%	0.0%	0.2%	0.4%	0.0%
Abiotic Depletion Potential, fossils	MJ LHV	98.0	0.706	148	3.80	1.25×10^{-2}	0.113	0.365	0.00
	%	39.0%	0.3%	59.0%	1.5%	0.0%	0.0%	0.1%	0.0%
Water use	m3	3.82	4.50×10^{-2}	4.32	0.242	3.86×10^{-3}	7.20×10^{-3}	0.439	0.00
	%	43.0%	0.5%	48.7%	2.7%	0.0%	0.1%	4.9%	0.0%

Table 18. Core Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms FGP Bench. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Core Indicators									
Acidification	molc H+ eq	2.63	7.83×10^{-2}	0.234	6.31×10^{-2}	2.27×10^{-3}	1.24×10^{-3}	6.25×10^{-3}	-1.72×10^{-4}
	%	87.2%	2.6%	7.8%	2.1%	0.1%	0.0%	0.2%	0.0%
Climate change - Biogenic	kg CO2 eq	-85.6	1.18×10^{-2}	-2.89	2.20×10^{-2}	9.54	4.34×10^{-4}	43.7	-2.12×10^{-4}
	%	243.0%	0.0%	8.2%	-0.1%	-27.1%	0.0%	-124.0%	0.0%
Climate change - Fossil	kg CO2 eq	295	5.79	65.8	12.5	0.406	0.245	0.590	-3.94×10^{-2}
	%	77.6%	1.5%	17.3%	3.3%	0.1%	0.1%	0.2%	0.0%
Climate change - Land use and LU change	kg CO2 eq	0.332	3.92×10^{-3}	0.120	4.94×10^{-3}	9.42×10^{-5}	9.73×10^{-5}	1.51×10^{-4}	-3.25×10^{-5}
	%	72.0%	0.8%	26.0%	1.1%	0.0%	0.0%	0.0%	0.0%
Climate Change - Total	kg CO2 eq	210	5.81	63.1	12.5	9.94	0.246	44.3	-3.96×10^{-2}
	%	60.7%	1.7%	18.3%	3.6%	2.9%	0.1%	12.8%	0.0%
Eutrophication, freshwater	kg PO_4 eq	0.156	5.12×10^{-4}	2.25×10^{-2}	8.15×10^{-4}	3.25×10^{-5}	1.61×10^{-5}	1.98×10^{-4}	-1.81×10^{-5}
	%	86.6%	0.3%	12.5%	0.5%	0.0%	0.0%	0.1%	0.0%
Eutrophication, marine	kg N eq	0.362	2.58×10^{-2}	7.23×10^{-2}	2.17×10^{-2}	8.54×10^{-3}	4.29×10^{-4}	3.11×10^{-3}	-4.09×10^{-5}
	%	73.3%	5.2%	14.6%	4.4%	1.7%	0.1%	0.6%	0.0%
Eutrophication, terrestrial	molc N eq	3.68	0.283	0.503	0.238	8.31×10^{-3}	4.68×10^{-3}	3.06×10^{-2}	-3.89×10^{-4}
	%	77.5%	6.0%	10.6%	5.0%	0.2%	0.1%	0.6%	0.0%
Ozone depletion	kg CFC11 eq	9.61×10^{-6}	1.14×10^{-6}	5.39×10^{-6}	2.91×10^{-6}	6.95×10^{-8}	5.73×10^{-8}	8.61×10^{-8}	-1.96×10^{-9}
	%	49.9%	5.9%	28.0%	15.1%	0.4%	0.3%	0.4%	0.0%
Photochemical ozone formation	kg MVOC eq	1.04	7.48×10^{-2}	0.131	6.67×10^{-2}	3.94×10^{-3}	1.31×10^{-3}	7.68×10^{-3}	-1.56×10^{-4}
	%	78.5%	5.6%	9.9%	5.0%	0.3%	0.1%	0.6%	0.0%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	7.59×10^{-4}	1.77×10^{-5}	1.63×10^{-4}	4.20×10^{-5}	1.02×10^{-6}	8.27×10^{-7}	1.98×10^{-6}	-3.93×10^{-7}
	%	77.0%	1.8%	16.6%	4.3%	0.1%	0.1%	0.2%	0.0%
Abiotic Depletion Potential, fossils	MJ LHV	3,250	10.8	350	14.3	0.400	0.281	1.28	-0.408
	%	89.6%	0.3%	9.6%	0.4%	0.0%	0.0%	0.0%	0.0%
Water use	m3	44.4	0.470	18.7	0.909	0.197	1.79×10^{-2}	0.540	-1.91×10^{-2}
	%	68.1%	0.7%	28.7%	1.4%	0.3%	0.0%	0.8%	0.0%

Table 19. Core Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Chipman Chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Core Indicators									
Acidification	molc H+ eq	1.46	4.34×10^{-2}	0.207	1.28×10^{-2}	4.61×10^{-4}	2.50×10^{-4}	9.11×10^{-4}	-3.45×10^{-5}
	%	84.7%	2.5%	12.0%	0.7%	0.0%	0.0%	0.1%	0.0%
Climate change - Biogenic	kg CO2 eq	-1.10	6.18×10^{-3}	-0.647	4.47×10^{-3}	1.97	8.74×10^{-5}	3.78×10^{-2}	-4.25×10^{-5}
	%	-399.7%	2.3%	-235.8%	1.6%	717.8%	0.0%	13.8%	0.0%
Climate change - Fossil	kg CO2 eq	161	3.00	63.5	2.52	7.17×10^{-2}	4.94×10^{-2}	0.117	-7.87×10^{-3}
	%	70.0%	1.3%	27.5%	1.1%	0.0%	0.0%	0.1%	0.0%
Climate change - Land use and LU change	kg CO2 eq	9.80×10^{-2}	2.12×10^{-3}	3.12×10^{-2}	1.00×10^{-3}	1.92×10^{-5}	1.96×10^{-5}	3.80×10^{-5}	-6.51×10^{-6}
	%	74.0%	1.6%	23.6%	0.8%	0.0%	0.0%	0.0%	0.0%
Climate Change - Total	kg CO2 eq	160	3.01	62.9	2.53	2.04	4.95×10^{-2}	0.155	-7.92×10^{-3}
	%	69.4%	1.3%	27.2%	1.1%	0.9%	0.0%	0.1%	0.0%
Eutrophication, freshwater	kg PO_4 eq	8.65×10^{-2}	2.73×10^{-4}	2.11×10^{-2}	1.65×10^{-4}	6.57×10^{-6}	3.23×10^{-6}	3.13×10^{-5}	-3.62×10^{-6}
	%	80.1%	0.3%	19.5%	0.2%	0.0%	0.0%	0.0%	0.0%
Eutrophication, marine	kg N eq	0.196	1.42×10^{-2}	4.03×10^{-2}	4.41×10^{-3}	1.72×10^{-3}	8.62×10^{-5}	3.58×10^{-4}	-8.18×10^{-6}
	%	76.2%	5.5%	15.7%	1.7%	0.7%	0.0%	0.1%	0.0%
Eutrophication, terrestrial	molc N eq	1.99	0.157	0.347	4.81×10^{-2}	1.68×10^{-3}	9.42×10^{-4}	3.81×10^{-3}	-7.77×10^{-5}
	%	78.1%	6.1%	13.6%	1.9%	0.1%	0.0%	0.1%	0.0%
Ozone depletion	kg CFC11 eq	4.83×10^{-6}	5.79×10^{-7}	4.79×10^{-6}	5.89×10^{-7}	1.41×10^{-8}	1.15×10^{-8}	3.14×10^{-8}	-3.93×10^{-10}
	%	44.5%	5.3%	44.2%	5.4%	0.1%	0.1%	0.3%	0.0%
Photochemical ozone formation	kg MVOC eq	0.552	4.13×10^{-2}	0.103	1.35×10^{-2}	8.07×10^{-4}	2.64×10^{-4}	1.07×10^{-3}	-3.12×10^{-5}
	%	77.5%	5.8%	14.5%	1.9%	0.1%	0.0%	0.1%	0.0%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	3.31×10^{-4}	9.05×10^{-6}	1.00×10^{-4}	8.50×10^{-6}	2.07×10^{-7}	1.66×10^{-7}	5.84×10^{-7}	-7.87×10^{-8}
	%	73.6%	2.0%	22.3%	1.9%	0.0%	0.0%	0.1%	0.0%
Abiotic Depletion Potential, fossils	MJ LHV	1,800	5.86	375	2.89	8.12×10^{-2}	5.66×10^{-2}	0.219	-8.17×10^{-2}
	%	82.5%	0.3%	17.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Water use	m3	21.7	0.246	13.1	0.184	3.96×10^{-2}	3.60×10^{-3}	0.153	-3.82×10^{-3}
	%	61.2%	0.7%	37.0%	0.5%	0.1%	0.0%	0.4%	0.0%

Table 20. Core Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Parc Center. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Core Indicators									
Acidification	molc H+ eq	9.74×10^{-2}	1.14×10^{-3}	0.163	1.43×10^{-2}	4.37×10^{-4}	3.09×10^{-4}	4.60×10^{-4}	-3.45×10^{-5}
	%	35.2%	0.4%	58.8%	5.2%	0.2%	0.1%	0.2%	0.0%
Climate change - Biogenic	kg CO2 eq	6.06×10^{-2}	3.99×10^{-4}	-0.516	5.00×10^{-3}	1.84	1.08×10^{-4}	2.25×10^{-2}	-4.25×10^{-5}
	%	4.3%	0.0%	-36.6%	0.4%	130.3%	0.0%	1.6%	0.0%
Climate change - Fossil	kg CO2 eq	20.6	0.226	51.0	2.82	6.88×10^{-2}	6.10×10^{-2}	7.36×10^{-2}	-7.87×10^{-3}
	%	27.6%	0.3%	68.1%	3.8%	0.1%	0.1%	0.1%	0.0%
Climate change - Land use and LU change	kg CO2 eq	0.165	8.94×10^{-5}	2.72×10^{-2}	1.12×10^{-3}	1.82×10^{-5}	2.42×10^{-5}	3.88×10^{-5}	-6.51×10^{-6}
	%	85.3%	0.0%	14.1%	0.6%	0.0%	0.0%	0.0%	0.0%
Climate Change - Total	kg CO2 eq	20.9	0.226	50.5	2.83	1.91	6.11×10^{-2}	9.62×10^{-2}	-7.92×10^{-3}
	%	27.3%	0.3%	66.0%	3.7%	2.5%	0.1%	0.1%	0.0%
Eutrophication, freshwater	kg PO_4 eq	9.58×10^{-3}	1.48×10^{-5}	1.63×10^{-2}	1.85×10^{-4}	6.34×10^{-6}	3.99×10^{-6}	2.21×10^{-5}	-3.62×10^{-6}
	%	36.7%	0.1%	62.5%	0.7%	0.0%	0.0%	0.1%	0.0%
Eutrophication, marine	kg N eq	1.93×10^{-2}	3.94×10^{-4}	3.30×10^{-2}	4.93×10^{-3}	1.62×10^{-3}	1.06×10^{-4}	2.58×10^{-4}	-8.18×10^{-6}
	%	32.4%	0.7%	55.4%	8.3%	2.7%	0.2%	0.4%	0.0%
Eutrophication, terrestrial	molc N eq	0.188	4.30×10^{-3}	0.280	5.39×10^{-2}	1.60×10^{-3}	1.16×10^{-3}	1.80×10^{-3}	-7.77×10^{-5}
	%	35.4%	0.8%	52.8%	10.2%	0.3%	0.2%	0.3%	0.0%
Ozone depletion	kg CFC11 eq	1.37×10^{-6}	5.26×10^{-8}	3.98×10^{-6}	6.59×10^{-7}	1.34×10^{-8}	1.42×10^{-8}	1.82×10^{-8}	-3.93×10^{-10}
	%	22.4%	0.9%	65.2%	10.8%	0.2%	0.2%	0.3%	0.0%
Photochemical ozone formation	kg MVOC eq	7.28×10^{-2}	1.21×10^{-3}	8.27×10^{-2}	1.51×10^{-2}	7.55×10^{-4}	3.26×10^{-4}	5.11×10^{-4}	-3.12×10^{-5}
	%	42.0%	0.7%	47.7%	8.7%	0.4%	0.2%	0.3%	0.0%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	2.23×10^{-4}	7.60×10^{-7}	7.98×10^{-5}	9.51×10^{-6}	1.96×10^{-7}	2.05×10^{-7}	1.32×10^{-7}	-7.87×10^{-8}
	%	71.1%	0.2%	25.5%	3.0%	0.1%	0.1%	0.0%	0.0%
Abiotic Depletion Potential, fossils	MJ LHV	176	0.259	288	3.24	7.73×10^{-2}	6.99×10^{-2}	0.127	-8.17×10^{-2}
	%	37.7%	0.1%	61.5%	0.7%	0.0%	0.0%	0.0%	0.0%
Water use	m3	13.9	1.65×10^{-2}	11.0	0.206	3.77×10^{-2}	4.45×10^{-3}	5.82×10^{-2}	-3.82×10^{-3}
	%	55.2%	0.1%	43.6%	0.8%	0.1%	0.0%	0.2%	0.0%

Table 21. Core Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Strata Bench. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Core Indicators									
Acidification	molc H+ eq	0.502	0.163	0.222	0.263	9.17×10^{-3}	5.80×10^{-3}	1.58×10^{-3}	-3.45×10^{-5}
	%	43.1%	14.0%	19.0%	22.5%	0.8%	0.5%	0.1%	0.0%
Climate change - Biogenic	kg CO2 eq	0.337	5.70×10^{-2}	-0.437	9.18×10^{-2}	25.9	2.03×10^{-3}	1.18×10^{-3}	-4.25×10^{-5}
	%	1.3%	0.2%	-1.7%	0.4%	99.8%	0.0%	0.0%	0.0%
Climate change - Fossil	kg CO2 eq	145	32.2	67.0	51.9	1.19	1.15	0.168	-7.87×10^{-3}
	%	48.5%	10.8%	22.5%	17.4%	0.4%	0.4%	0.1%	0.0%
Climate change - Land use and LU change	kg CO2 eq	0.215	1.28×10^{-2}	3.03×10^{-2}	2.06×10^{-2}	3.75×10^{-4}	4.54×10^{-4}	1.55×10^{-4}	-6.51×10^{-6}
	%	76.9%	4.6%	10.8%	7.3%	0.1%	0.2%	0.1%	0.0%
Climate Change - Total	kg CO2 eq	145	32.3	66.6	52.0	27.1	1.15	0.169	-7.92×10^{-3}
	%	44.8%	9.9%	20.5%	16.0%	8.3%	0.4%	0.1%	0.0%
Eutrophication, freshwater	kg PO_4 eq	4.49×10^{-2}	2.11×10^{-3}	2.20×10^{-2}	3.39×10^{-3}	1.88×10^{-4}	7.49×10^{-5}	1.61×10^{-5}	-3.62×10^{-6}
	%	61.8%	2.9%	30.2%	4.7%	0.3%	0.1%	0.0%	0.0%
Eutrophication, marine	kg N eq	0.125	5.62×10^{-2}	4.45×10^{-2}	9.06×10^{-2}	2.40×10^{-2}	2.00×10^{-3}	5.50×10^{-4}	-8.18×10^{-6}
	%	36.4%	16.4%	13.0%	26.4%	7.0%	0.6%	0.2%	0.0%
Eutrophication, terrestrial	molc N eq	1.39	0.614	0.394	0.990	3.91×10^{-2}	2.18×10^{-2}	6.02×10^{-3}	-7.77×10^{-5}
	%	40.2%	17.8%	11.4%	28.6%	1.1%	0.6%	0.2%	0.0%
Ozone depletion	kg CFC11 eq	5.84×10^{-6}	7.51×10^{-6}	5.29×10^{-6}	1.21×10^{-5}	3.20×10^{-7}	2.67×10^{-7}	6.80×10^{-8}	-3.93×10^{-10}
	%	18.6%	23.9%	16.8%	38.6%	1.0%	0.9%	0.2%	0.0%
Photochemical ozone formation	kg MVOC eq	0.416	0.172	0.119	0.278	1.19×10^{-2}	6.13×10^{-3}	1.71×10^{-3}	-3.12×10^{-5}
	%	41.4%	17.1%	11.8%	27.6%	1.2%	0.6%	0.2%	0.0%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	9.00×10^{-4}	1.08×10^{-4}	1.23×10^{-4}	1.75×10^{-4}	3.85×10^{-6}	3.86×10^{-6}	3.62×10^{-7}	-7.87×10^{-8}
	%	68.5%	8.3%	9.4%	13.3%	0.3%	0.3%	0.0%	0.0%
Abiotic Depletion Potential, fossils	MJ LHV	906	36.9	396	59.5	1.82	1.31	0.352	-8.17×10^{-2}
	%	64.6%	2.6%	28.2%	4.2%	0.1%	0.1%	0.0%	0.0%
Water use	m3	88.3	2.35	14.0	3.79	0.883	8.36×10^{-2}	0.216	-3.82×10^{-3}
	%	80.5%	2.1%	12.8%	3.5%	0.8%	0.1%	0.2%	0.0%

Table 22. Life Cycle Impact Assessment Results by life cycle phase for the Loll Products Adirondack chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Additional Indicators									
Freshwater ecotoxicity	PAF.m3.day	20.6	0.310	0.801	1.66	5.31×10^{-3}	4.96×10^{-2}	0.196	0.00
	%	87.2%	1.3%	3.4%	7.0%	0.0%	0.2%	0.8%	0.0%
Human toxicity, cancer	CTUh	5.43×10^{-8}	2.01×10^{-10}	3.22×10^{-9}	1.08×10^{-9}	5.64×10^{-12}	3.21×10^{-11}	2.99×10^{-10}	0.00
	%	91.8%	0.3%	5.4%	1.8%	0.0%	0.1%	0.5%	0.0%
Human toxicity, non-cancer	CTUh	6.15×10^{-7}	1.15×10^{-8}	5.11×10^{-7}	6.19×10^{-8}	7.60×10^{-10}	1.84×10^{-9}	5.65×10^{-8}	0.00
	%	48.9%	0.9%	40.6%	4.9%	0.1%	0.1%	4.5%	0.0%
Land use	Pt	45.5	7.83	14.0	42.1	0.199	1.25	12.5	0.00
	%	36.9%	6.3%	11.4%	34.1%	0.2%	1.0%	10.1%	0.0%
Particulate Matter emissions	Disease inc.	1.32×10^{-6}	4.44×10^{-8}	3.21×10^{-7}	2.38×10^{-7}	8.29×10^{-10}	7.10×10^{-9}	2.72×10^{-8}	0.00
	%	67.4%	2.3%	16.4%	12.2%	0.0%	0.4%	1.4%	0.0%
Ionizing Radiation, human health	kBq U-235 eq	3.49	4.83×10^{-2}	2.59	0.259	1.07×10^{-3}	7.73×10^{-3}	2.44×10^{-2}	0.00
	%	54.3%	0.8%	40.4%	4.0%	0.0%	0.1%	0.4%	0.0%

Table 23. Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms FGP Bench. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Additional Indicators									
Freshwater ecotoxicity	PAF.m3.day	67.6	1.36	40.5	6.26	0.124	0.123	0.373	-9.19×10^{-3}
	%	58.1%	1.2%	34.8%	5.4%	0.1%	0.1%	0.3%	0.0%
Human toxicity, cancer	CTUh	2.93×10^{-7}	3.18×10^{-9}	2.69×10^{-8}	4.06×10^{-9}	2.17×10^{-10}	8.00×10^{-11}	1.36×10^{-9}	-2.25×10^{-10}
	%	89.2%	1.0%	8.2%	1.2%	0.1%	0.0%	0.4%	-0.1%
Human toxicity, non-cancer	CTUh	2.87×10^{-5}	9.45×10^{-8}	1.58×10^{-6}	2.33×10^{-7}	3.01×10^{-8}	4.59×10^{-9}	1.88×10^{-7}	-2.10×10^{-9}
	%	93.1%	0.3%	5.1%	0.8%	0.1%	0.0%	0.6%	0.0%
Land use	Pt	468	39.5	145	158	10.3	3.12	13.5	-9.65×10^{-2}
	%	55.8%	4.7%	17.4%	18.9%	1.2%	0.4%	1.6%	0.0%
Particulate Matter emissions	Disease inc.	1.71×10^{-5}	4.58×10^{-7}	2.13×10^{-6}	8.97×10^{-7}	3.05×10^{-8}	1.77×10^{-8}	8.15×10^{-8}	-3.02×10^{-9}
	%	82.6%	2.2%	10.3%	4.3%	0.1%	0.1%	0.4%	0.0%
Ionizing Radiation, human health	kBq U-235 eq	17.4	0.391	7.61	0.976	3.31×10^{-2}	1.92×10^{-2}	5.95×10^{-2}	-1.87×10^{-3}
	%	65.7%	1.5%	28.7%	3.7%	0.1%	0.1%	0.2%	0.0%

Table 24. Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Chipman chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Additional Indicators									
Freshwater ecotoxicity	PAF.m3.day	23.8	0.615	11.7	1.27	$2.54x10^{-2}$	$2.48x10^{-2}$	0.184	$-1.84x10^{-3}$
	%	63.2%	1.6%	31.2%	3.4%	0.1%	0.1%	0.5%	0.0%
Human toxicity, cancer	CTUh	$1.21x10^{-7}$	$1.72x10^{-9}$	$2.03x10^{-8}$	$8.22x10^{-10}$	$4.38x10^{-11}$	$1.61x10^{-11}$	$2.61x10^{-10}$	$-4.50x10^{-11}$
	%	84.0%	1.2%	14.1%	0.6%	0.0%	0.0%	0.2%	0.0%
Human toxicity, non-cancer	CTUh	$1.61x10^{-5}$	$4.82x10^{-8}$	$1.29x10^{-6}$	$4.72x10^{-8}$	$6.10x10^{-9}$	$9.23x10^{-10}$	$7.35x10^{-9}$	$-4.20x10^{-10}$
	%	92.0%	0.3%	7.4%	0.3%	0.0%	0.0%	0.0%	0.0%
Land use	Pt	238	18.4	65.1	32.1	2.07	0.628	7.34	$-1.93x10^{-2}$
	%	65.5%	5.1%	17.9%	8.8%	0.6%	0.2%	2.0%	0.0%
Particulate Matter emissions	Disease inc.	$8.55x10^{-6}$	$2.39x10^{-7}$	$1.15x10^{-6}$	$1.82x10^{-7}$	$6.17x10^{-9}$	$3.56x10^{-9}$	$1.96x10^{-8}$	$-6.03x10^{-10}$
	%	84.2%	2.4%	11.3%	1.8%	0.1%	0.0%	0.2%	0.0%
Ionizing Radiation, human health	kBq U-235 eq	9.20	0.198	8.83	0.198	$6.77x10^{-3}$	$3.87x10^{-3}$	$2.86x10^{-2}$	$-3.74x10^{-4}$
	%	49.8%	1.1%	47.8%	1.1%	0.0%	0.0%	0.2%	0.0%

Table 25. Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Parc Center chair. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Additional Indicators									
Freshwater ecotoxicity	PAF.m3.day	30.7	0.113	10.3	1.42	$2.37x10^{-2}$	$3.06x10^{-2}$	$6.07x10^{-2}$	$-1.84x10^{-3}$
	%	71.9%	0.3%	24.2%	3.3%	0.1%	0.1%	0.1%	0.0%
Human toxicity, cancer	CTUh	$1.70x10^{-7}$	$7.35x10^{-11}$	$1.60x10^{-8}$	$9.20x10^{-10}$	$4.17x10^{-11}$	$1.99x10^{-11}$	$8.23x10^{-11}$	$-4.50x10^{-11}$
	%	90.8%	0.0%	8.6%	0.5%	0.0%	0.0%	0.0%	0.0%
Human toxicity, non-cancer	CTUh	$1.23x10^{-6}$	$4.22x10^{-9}$	$9.88x10^{-7}$	$5.28x10^{-8}$	$5.75x10^{-9}$	$1.14x10^{-9}$	$1.27x10^{-9}$	$-4.20x10^{-10}$
	%	53.9%	0.2%	43.2%	2.3%	0.3%	0.0%	0.1%	0.0%
Land use	Pt	66.2	2.87	54.7	35.9	2.00	0.775	2.29	$-1.93x10^{-2}$
	%	40.2%	1.7%	33.2%	21.8%	1.2%	0.5%	1.4%	0.0%
Particulate Matter emissions	Disease inc.	$1.29x10^{-6}$	$1.62x10^{-8}$	$8.86x10^{-7}$	$2.03x10^{-7}$	$5.91x10^{-9}$	$4.39x10^{-9}$	$1.05x10^{-8}$	$-6.03x10^{-10}$
	%	53.4%	0.7%	36.7%	8.4%	0.2%	0.2%	0.4%	0.0%
Ionizing Radiation, human health	kBq U-235 eq	2.38	$1.77x10^{-2}$	6.77	0.221	$6.39x10^{-3}$	$4.78x10^{-3}$	$5.83x10^{-3}$	$-3.74x10^{-4}$
	%	25.3%	0.2%	72.0%	2.4%	0.1%	0.1%	0.1%	0.0%

Table 26. Life Cycle Impact Assessment Results by life cycle phase for the Landscape Forms Strata Bench. Results are shown for one chair maintained for 15 years.

Impact Category	Unit	A1	A2	A3	A4	A5	C2	C4	D
Additional Indicators									
Freshwater ecotoxicity	PAF.m3.day	62.4	16.2	12.5	26.1	0.370	0.576	3.40×10^{-2}	-1.84×10^{-3}
	%	52.8%	13.7%	10.6%	22.1%	0.3%	0.5%	0.0%	0.0%
Human toxicity, cancer	CTUh	7.74×10^{-7}	1.05×10^{-8}	3.37×10^{-8}	1.69×10^{-8}	9.24×10^{-10}	3.73×10^{-10}	6.62×10^{-11}	-4.50×10^{-11}
	%	92.5%	1.3%	4.0%	2.0%	0.1%	0.0%	0.0%	0.0%
Human toxicity, non-cancer	CTUh	5.22×10^{-6}	6.02×10^{-7}	1.37×10^{-6}	9.70×10^{-7}	1.03×10^{-7}	2.14×10^{-8}	2.31×10^{-9}	-4.20×10^{-10}
	%	63.0%	7.3%	16.5%	11.7%	1.2%	0.3%	0.0%	0.0%
Land use	Pt	296	409	91.6	660	58.2	14.6	7.99	-1.93×10^{-2}
	%	19.3%	26.6%	6.0%	42.9%	3.8%	0.9%	0.5%	0.0%
Particulate Matter emissions	Disease inc.	5.88×10^{-6}	2.32×10^{-6}	1.35×10^{-6}	3.74×10^{-6}	1.53×10^{-7}	8.25×10^{-8}	3.10×10^{-8}	-6.03×10^{-10}
	%	43.4%	17.1%	10.0%	27.6%	1.1%	0.6%	0.2%	0.0%
Ionizing Radiation, human health	kBq U-235 eq	9.37	2.52	9.17	4.07	0.126	8.97×10^{-2}	2.08×10^{-2}	-3.74×10^{-4}
	%	36.9%	9.9%	36.1%	16.0%	0.5%	0.4%	0.1%	0.0%

The *A1* life cycle phase is the largest contributor to the impact indicators evaluated. Impacts from modules downstream of the manufacturing facility are generally less than ~10-20% of the overall life cycle of the products while the manufacturing (A3) stage impacts are minimal. Extraction and processing of nylon and steel components are the main contributors to the A1 phase while impact contributions for the A3 production phase are primarily due to natural gas usage. Impacts to RPRE in A3 for the Strata Bench are negative due to the high renewable material in the packaging.

Product distribution dominates the downstream stage impacts and reflects the geographic variability of the product-specific distribution. Variation of disposal rates across geographic regions are not expected to affect the overall life cycle impacts of the assessed products. A review of the modeling results for the Global Warming Potential indicators shows the upstream impacts for the seating products are dominated by the aluminum and steel material components contributing over 65% to total life cycle impacts. Other indicators exhibit similar trends in impact contributions.

4.4 Sensitivity Analysis

Sensitivity analyses are conducted to evaluate the impact of various modeling assumptions on indicator results, including alternative product material components. The sensitivity analyses conducted as part of the study are summarized below.

The products assessed include aluminum and steel components with some recycled content. To evaluate the effect of the proposed seating product design on the estimated impact indicators, the product system was modeled with two modified EN15804 datasets to represent both increased and decreased recycled content in steel and aluminum product components.

The results of the sensitivity modeling are presented for the Landscape Forms seating products below. Results are shown for single product maintained for a 15-year period. For all impact category indicators provided in Tables 27-31, decreases in the estimated impacts range from <1% to 15% for the proposed seating constructed with a 10% increase in recycled content for aluminum and steel product components.

Table 27. Life Cycle Impact Assessment Results for the Landscape Forms ADK Chair seating product assuming a change in recycled content. Results are shown for a single product maintained for 15 years.

Impact Category	Units	Impact (Current)	*+10% Recycled Content*	% Difference (+10% Recycled Content)	*-10% Recycled Content*	% Difference (-10% Recycled Content)
Core Indicators						
Acidification	molc H+ eq	0.142	0.141	-0.39%	0.142	0.39%
Climate Change	kg CO2 eq	40.6	40.5	-0.21%	40.7	0.20%
Eutrophication, freshwater	kg P eq	2.69×10^{-2}	2.68×10^{-2}	-0.10%	2.69×10^{-2}	0.10%
Eutrophication, marine	kg N eq	6.48×10^{-2}	6.47×10^{-2}	-0.14%	6.49×10^{-2}	0.14%
Eutrophication, terrestrial	molc N eq	0.304	0.303	-0.31%	0.305	0.30%
Ozone depletion	kg CFC11 eq	2.69×10^{-6}	2.69×10^{-6}	-0.10%	2.70×10^{-6}	0.10%
Photochemical ozone formation	kg NMVOC eq	9.81×10^{-2}	9.79×10^{-2}	-0.26%	9.84×10^{-2}	0.25%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	1.79×10^{-4}	1.80×10^{-4}	0.13%	1.79×10^{-4}	-0.13%
Abiotic Depletion Potential, fossils	MJ LHV	251	250	-0.33%	252	0.33%
Water use	m3	8.88	8.86	-0.18%	8.89	0.18%

Table 28. Life Cycle Impact Assessment Results for the Landscape Form FGP Bench seating product assuming a change in recycled content. Results are shown for a single product maintained for 15 years.

Impact Category	Units	Impact (Current)	*+10% Recycled Content*	% Difference (+10% Recycled Content)	*-10% Recycled Content*	% Difference (-10% Recycled Content)
Core Indicators						
Acidification	molc H+ eq	3.01	2.82	-6.88%	3.39	11.15%
Climate Change	kg CO2 eq	345	307	-12.46%	367	5.75%
Eutrophication, freshwater	kg P eq	0.180	0.171	-5.46%	0.205	12.16%
Eutrophication, marine	kg N eq	0.494	0.508	2.83%	0.582	15.13%
Eutrophication, terrestrial	molc N eq	4.75	4.68	-1.55%	5.42	12.40%
Ozone depletion	kg CFC11 eq	1.93×10^{-5}	2.01×10^{-5}	4.34%	2.18×10^{-5}	11.64%
Photochemical ozone formation	kg NMVOC eq	1.33	1.29	-2.68%	1.50	11.42%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	9.85×10^{-4}	4.98×10^{-4}	-97.88%	9.47×10^{-4}	-4.08%
Abiotic Depletion Potential, fossils	MJ LHV	3,630	1,990	-82.25%	4,050	10.33%
Water use	m3	65.2	34.8	-87.42%	77.4	15.85%

Table 29. Life Cycle Impact Assessment Results for the Landscape Forms Chipman Chair seating product assuming a change in recycled content. Results are shown for a single product maintained for 15 years.

Impact Category	Units	Impact (Current)	*+10% Recycled Content*	% Difference (+10% Recycled Content)	*-10% Recycled Content*	% Difference (-10% Recycled Content)
Core Indicators						
Acidification	molc H+ eq	1.72	1.56	-10.54%	1.89	8.71%
Climate Change	kg CO2 eq	231	214	-7.95%	248	6.86%
Eutrophication, freshwater	kg P eq	0.108	9.82×10^{-2}	-10.00%	0.118	8.33%
Eutrophication, marine	kg N eq	0.257	0.236	-8.96%	0.278	7.60%
Eutrophication, terrestrial	molc N eq	2.55	2.33	-9.16%	2.76	7.74%
Ozone depletion	kg CFC11 eq	1.08×10^{-5}	1.04×10^{-5}	-4.59%	1.13×10^{-5}	4.21%
Photochemical ozone formation	kg NMVOC eq	0.711	0.653	-9.02%	0.770	7.64%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	4.49×10^{-4}	4.98×10^{-4}	9.74%	4.01×10^{-4}	-12.09%
Abiotic Depletion Potential, fossils	MJ LHV	2,190	1,990	-9.85%	2,380	8.23%
Water use	m3	35.5	34.8	-2.09%	36.2	2.00%

Table 30. Life Cycle Impact Assessment Results for the Landscape Forms Parc Center Chair seating product assuming a change in recycled content. Results are shown for a single product maintained for 15 years.

Impact Category	Units	Impact (Current)	*+10% Recycled Content*	% Difference (+10% Recycled Content)	*-10% Recycled Content*	% Difference (-10% Recycled Content)
Core Indicators						
Acidification	molc H+ eq	0.277	0.270	-2.67%	0.284	2.53%
Climate Change	kg CO2 eq	76.5	74.7	-2.36%	78.2	2.25%
Eutrophication, freshwater	kg P eq	2.61×10^{-2}	2.54×10^{-2}	-3.02%	2.69×10^{-2}	2.84%
Eutrophication, marine	kg N eq	5.97×10^{-2}	5.81×10^{-2}	-2.72%	6.12×10^{-2}	2.58%
Eutrophication, terrestrial	molc N eq	0.530	0.513	-3.35%	0.548	3.14%
Ozone depletion	kg CFC11 eq	6.10×10^{-6}	6.03×10^{-6}	-1.13%	6.17×10^{-6}	1.11%
Photochemical ozone formation	kg NMVOC eq	0.173	0.166	-4.57×10^{-2}	0.181	4.19×10^{-2}
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	3.13×10^{-4}	4.98×10^{-4}	0.370	3.43×10^{-4}	8.69×10^{-2}
Abiotic Depletion Potential, fossils	MJ LHV	468	1,990	0.765	490	4.35×10^{-2}
Water use	m3	25.3	34.8	0.273	25.4	6.26×10^{-3}

Table 31. Life Cycle Impact Assessment Results for the Landscape Forms Strata Bench seating product assuming a change in recycled content. Results are shown for a single product maintained for 15 years.

Impact Category	Units	Impact (Current)	*+10% Recycled Content*	% Difference (+10% Recycled Content)	*-10% Recycled Content*	% Difference (-10% Recycled Content)
Core Indicators						
Acidification	molc H+ eq	1.17	1.14	-2.03%	1.19	1.95%
Climate Change	kg CO2 eq	325	319	-1.78%	330	1.72%
Eutrophication, freshwater	kg P eq	7.26×10^{-2}	7.02×10^{-2}	-3.51%	7.51×10^{-2}	3.28%
Eutrophication, marine	kg N eq	0.343	0.337	-1.51%	0.348	1.47%
Eutrophication, terrestrial	molc N eq	3.45	3.40	-1.63%	3.51	1.58%
Ozone depletion	kg CFC11 eq	3.14×10^{-5}	3.12×10^{-5}	-0.71%	3.16×10^{-5}	0.70%
Photochemical ozone formation	kg NMVOC eq	1.00	0.980	-2.49%	1.03	2.37%
Abiotic Depletion Potential, minerals and metals	kg Sb-Eq	1.31×10^{-3}	4.98×10^{-4}	-1.64	1.41×10^{-3}	6.82×10^{-2}
Abiotic Depletion Potential, fossils	MJ LHV	1,400	1,990	0.297	1,470	4.68×10^{-2}
Water use	m3	110	34.8	-2.15	110	4.66×10^{-3}

5. Interpretation and Recommendations

A life cycle assessment of the Landscape Forms outdoor furniture was conducted to support the preparation of five Environmental Product Declarations (EPD) based on the EPD Norge® System Product Category Rule (PCR) for Furniture. Impact category indicator results are presented in Section 4.

The assessment relied on a number of assumptions and limitations, the most relevant of which are discussed in this report. Most of the upstream raw materials extraction and processing could not be modeled with actual process information. Representative data from the Ecoinvent EN15804 databases were utilized as appropriate. These datasets were modified to represent the Landscape Forms product systems, where necessary.

Life cycle inventory results were reviewed for completeness, consistency, and representativeness. Overall, the inventory was considered consistent and generally representative of the product system, with respect to the impact categories assessed. The primary source of data used during the assessment was from the manufacturer, with the remaining derived from the Ecoinvent EN15804 life cycle inventory database and other sources as described in this report. To the extent possible, validity checks of primary data were performed including mass balance and resource allocation calculations. Data validity checks were conducted during data collection as well as within the LCA modeling system.

A contribution analysis shows the *A1* life cycle phase is the largest contributor to the impact indicators evaluated. Production (A3) impacts are generally less than ~20-25% of the overall life cycle of the products while the downstream stage impacts are minimal. The contribution analysis suggests improvements in the assessment may be realized through collection and incorporation of primary resource use data for the various component manufacturing processes.

A sensitivity analysis evaluated the impact of two alternative product design incorporating both increased and recycled content of the steel and aluminum components. The analysis indicates small to significant decreases (up to 10%) in impact indicator results could be realized with the increased use of recycled steel and aluminum in the product, as well as a 15% increase in impact indicator results with a corresponding decrease in recycled content of steel and aluminum.

It is noted that the LCIA results presented in this report are relative expressions and do not predict impacts on category endpoints, exceedance of thresholds, safety margins, or risks associated with the product system. Impact indicators rely on the use of generic models and potential impacts and therefore are not able to measure actual environmental impacts. Additionally, the indicators prescribed by the PCR do not represent all categories of potential environmental and human health impacts associated with the life cycle of Landscape Forms products, and this represents a general limitation of the LCA study.

Appendix A: Critical Review Report

To be inserted.

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SCS Global Services

June 25th, 2024

Verification Statement for EPDs of Landscape Forms as per the SCS Global Services EPD program

Introduction

The Athena Sustainable Materials Institute (www.athenasmi.org) was engaged to perform third-party verification of the Landscape Forms LCA report and EPDs conducted by SCS Global Services (https://www.scsglobalservices.com/).
Lindita Bushi, Ph.D., an approved third-party verifier by the SCS Global Services EPD program, completed the verification.

The verifier reviewed the first draft and verified the final version of the Landscape Forms LCA report and EPDs dated June 25, 2024, in accordance with the following:

1. *EPD-NORGE, NPCR PART A: Construction products and services, Version: 2.0, Issue date: 24.03.2021, Valid to: 24.03.2026*,
2. *EPD-NORGE, Product Category Rule for Furniture. Product Category Classification: NPCR 026. EPD Norge®. Version 2.0. September 2022, EXP-2024-07-01.*
3. SCS Type III Environmental Declaration Program: Program Operator Manual. V12.0 November 2023. SCS Global Services,
4. *ISO standards* listed below –
   ISO 14025:2006 Environmental labels and declarations - Type III environmental declarations - Principles and procedures,
   ISO 14044:2006/Amd1:2017/Amd2:2020 Environmental Management - Life Cycle Assessment - Requirements and Guidelines.
   ISO 14040:2006/Amd1:2020 Environmental Management – Life cycle assessment – Principles and Framework
   EN 15804:2012+A2:2019 Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products.

Verification Statement

After a detailed examination, the verifier confirms that *no relevant deviations* within the EPDs and its supporting project report have been established concerning:

- The underlying data collected as used for the LCA calculations,
- The way the LCA-based calculations have been carried out to comply with the calculation rules described in the reference PCR,
- The presentation of environmental performance included in the EPD, and
- Other additional environmental information included in the declaration.

Further, no material deviations were found concerning the procedural and methodological requirements in ISO 14025:2006, ISO 14044:2006, EN 15804:2012+A2:2019, and SCS Global Services POR 2023.

EPD registration number(s):	*Provided by the SCS Global Services EPD program*
Product(s):	Landscape Forms | Adirondack Chair; Landscape Forms | Strata Bench Landscape Forms | Chipman Chair; Landscape Forms | FGP Bench Landscape Forms | Parc Centre Chair
Organization:	Landscape Forms, Inc. 7800 East Michigan Ave., Kalamazoo, MI 49048 www.landscapeforms.com
PCR:	EPD-NORGE, Product Category Rule for Furniture. Product Category Classification: NPCR 026. EPD Norge®. Version 2.0. September 2022, EXP-2024-07-01.
Validity of EPD:	Five years

The verifier confirms that the LCA-based data has been examined for plausibility and consistency; the declaration owner is responsible for its factual integrity and that the product does not violate relevant legislation.

The verifier confirms that she has sufficient knowledge and experience of declared products, relevant standards, and the geographical area of the EPDs to carry out this verification.

The verifier confirms that she has been independent in her role as a verifier in accordance with the ISO 14025 requirements, e.g., she has not been involved in the execution of the LCA or the development of the declarations and has no conflicts of interest regarding this verification.

Based on the verification objectives, the LCA/LCI data were determined to be ***in conformance*** with the relevant program operator rules, product category rules and applicable ISO standards. The plausibility of the LCA-based data, the quality and accuracy of the LCA-based data, and additional environmental information and supporting information are also confirmed.

A copy of the Landscape Forms verification statement (in PDF) and verification report (in Excel) *from June 25, 2024,* is provided to the SCS Global Services EPD program operator. As per ISO 14025, Clause 8.1.4, the verification report shall be made available to any interested party upon request.

The verifier appreciates the professional responsiveness of the SCS Global Services LCA team to all technical queries and comments and that of all parties involved in the verification process.

Name and organization of independent verifier:	**Address:**
Lindita Bushi, Ph.D., LEED Green Associate Athena Sustainable Materials Institute D: 416 269 8571 E: lindita.bushi@athenasmi.org	280 Albert St., Suite 404, Ottawa ON, K1P 5G8 http://www.athenasmi.org

Signature:

Lindita Bushi

Enclosed:
Verification report- EN 15804+A2 SCS Landscape Forms LCA report, EPDs, 25062024, Final.